ENGINEERING

OF MICHIGAN
JUN 30 1950
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RATOR TRAINING:
CHEME
ITS RESULTS

ADVANCING ROTODYNE

KING TO AMERICANS:
ERICA IS GOING PLACES
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AIN HARDENING
D THE DILATION OF
ESSURISED CYLINDERS

CE
2/-

-water quenching

What goes on at the Bloody Tower?

'They're changing over from D.C. to A.C. Hence the new cabling.'

'Supplied by Johnson & Phillips, I notice.'

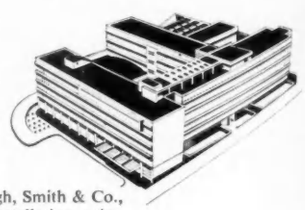
'And installed by them as well. J. & P. are seeing the whole job through.'

'So "power for the Tower" is another J. & P. enterprise?'

'Yes, they're versatile people.'

J. & P. POWER POINTS

ANCIENT & MODERN



J. & P. contracts range from historic buildings like the Tower of London to the magnificent new Amber House in Kampala, which will be occupied by the Uganda Electricity Board. J. & P.'s local agents, Clough, Smith & Co., are handling the electrical installation, using J. & P. p.v.c. wiring cables throughout.

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Something for Nothing

THE value to industry of the research associations—a subject on which we commented three weeks ago in this column—came up again last week with the publication of an official report (*Research for Industry:* A summary of work done by the industrial research associations in the Government scheme. Department of Scientific and Industrial Research. H.M. Stationery Office, 7*s.* 6*d.*).

Industrial firms provide most of the money for these associations, but the Government give encouragement and financial help. When the system was started 40 years ago, it was set in motion by a £1 million fund from the Government, the idea being that after that amount was spent, industry itself would be sufficiently aware of the benefits of co-operative research to pay for the whole of it in the future. But it takes a long time to educate everyone, and the appearance of getting something for nothing (because the State pays for part of the research) is useful for recruiting.

Each one of the research associations serves a particular or related group of industries, some of which are concerned directly or indirectly with the food we eat, the clothes we wear, the furniture, tools and instruments we use, our transport, the basic materials used day by day, whether it be fuels, such as coal or coke, ferrous or non-ferrous metals, or non-metallic materials such as paint, paper, glass, timber and ceramics.

The purpose of the co-operative research association scheme is to encourage groups of firms to co-operate in the study of their common scientific and engineering problems. The associations set up by such groups have received from DSIR annual grants roughly proportional to the income they raise independently through their member firms. There are now 39 associations in the scheme, together with seven research institutes on the same pattern. Three other bodies providing a common service to industry—Aslib, the National Institute of Industrial Psychology, and the Commonwealth Mycological Institute—also receive financial aid. The associations' income for the last financial year was £6 million (of which £1½ million was by Government grants), as compared with a total income of £1½ million in 1946 and £4 million in 1950. It was always intended that the research associations should eventually become more and more self-supporting, and the Government must be pleased with the general trend to date.

The success of the research associations, however, cannot be gauged merely by the growth of financial income, or determined by the extent to which they have become independent of Government support, but rather by the adequacy and use made of the research and development facilities which they provide for the groups of industries they are intended to serve. Related questions are whether or not they meet the requirements of both small and large firms, and the extent to which the work of the associations has resulted in improved or more economical production. Further, one might ask whether British industry as a whole is best served by voluntary membership (some research associations are supported by levies on the whole of the industry) and whether all branches of industry are equally well served. On the present pattern it would appear that the more prosperous the industry the better equipped and more efficient is its research association likely to be, whereas an industry which is very much in need of new ideas and improved techniques may not be in a position to support a research association.

It will be evident to all readers of the report that these considerations should not detract from the usefulness of the work already being done by the research associations. For example, the British Coal Utilisation Research Association have developed an automatic temperature controller for a small-pipe forced-circulation central heating system which is easily installed in existing houses; it is also hoped that a new design of ash-pan for locomotive boilers will enable inferior coal to be used instead of the large coal now used, some 3¼ million tons of which has to be imported each year to meet such demands. This association, and others like the British Ceramic R.A., are doing work to assist the implementation of the Clean Air Act. The Motor Industry R.A. is studying how to suppress noise in motor vehicles by lining with suitable damping materials, while the British Shipbuilding R.A. and PAMETRADA are collaborating in studying the marine application of nuclear energy. The British Cotton Industry R.A. are developing flame-resistant clothing, and fabrics have also been developed which are exceptionally water and wind proof, and yet are sufficiently permeable to air to form garments which are comfortable to wear.

An annual expenditure of £6 million is little enough in relation to the practical results which can be achieved. The financial resources have grown in recent years, and if they continue to grow the ideal of the originators of the scheme may eventually be realised.

Cover Picture. *Aluminium-alloy sand castings are shown being removed from a hot-water quenching tank, following a solution heat-treatment carried out at over 500° C. The castings are for use in controlling the hot-air flow from jet-engine air compressors.*

* * *

Plain Words

When the president of the senior engineering institution pleads for a single representative body of engineers in Britain, you can be sure that behind his remarks there is a good deal of discussion going on among the councils and secretaries of all the institutions. Sir Arthur Whitaker, President of the Institution of Civil Engineers, made this plea at the institution's annual dinner last week. He said that certainly the three major bodies of engineers in this country now worked well together, but he hoped they were going to see how much nearer they could get to one another.

The presidents and secretaries of the Institutions of Civil, Mechanical, and Electrical Engineers had recently returned from a Commonwealth tour, during which they managed to visit most of the joint overseas groups of the institutions. Such an important team representative of the profession carries considerable weight: in Singapore, for example, a dinner in their honour was attended by the Prime Minister and five members of the Cabinet. This overseas tour was the first occasion on which the presidents and secretaries of the three institutions went together as a group and was evidence of the close collaboration which has been developed between them.

The I.Mech.E. and the I.E.E. have grown rapidly in membership. By organising their memberships in geographical groups and specialised subject groups, they have provided for the individual member's interests in a reasonably satisfactory way. The three institutions have joined forces, with other societies, in the British Nuclear Energy Conference. These organisational developments have been designed to keep pace with changing requirements of the profession, but Sir Arthur clearly envisages something more at the top. Even if collaboration or integration is restricted to the three major institutions, there are formidable practical difficulties, but if, as would be inevitable, some consideration were given to such institutions as the Chemical Engineers, the Municipal Engineers, the Structural Engineers, and the Production Engineers (to name only a few), then the complications would be multiplied. All this, however, is no reason why the issue should be conveniently ignored. The senior president has spoken out, though in a guarded manner, and everyone with the profession's interests at heart will wonder where it will lead.

(At the Cambridge May Races, I hear, the Selwyn 4th boat carried a pennant labelled "The Chartered Engineer." An indication of what to-day's undergraduates will be organising to-morrow?)

CAPRICORN

Weekly Survey

Agonising Appraisals

The scientist and administrator (which in this case is a euphemism for the man who holds the purse strings) rarely agree about the order of priority in scientific research, be it fundamental or applied. There are at times abundant indications that they do not even agree on the need for a list of priorities at all. The most recent example of how scientific enterprise and curiosity runs foul of national spending policy has been a remark by Professor Lovell, the director of the Jodrell Bank Experimental Station. Professor Lovell has headed a team which has done excellent work on tracking satellites and, as might be expected, he has urged the need for this country to put a satellite into orbit. His remark that for the outlay of a few million pounds this country can adapt the present plans for ballistic rockets to an earth satellite seems eminently reasonable. The phrase "a few million pounds" builds up a tantalising picture of how much might be known in this field by British scientists if they could get a little more money a little more quickly. They may well be right.

This problem of how far endeavour should be pushed in any one direction is likely to get worse. This country is gradually spending more money on research and channelling more manpower into the application of fundamental and applied research to commercial enterprise. This is bound to create a ferment of ideas and possibly make more acute the disagreement between the scientists and non-scientist. Scientists are going to ask for more money and more facilities. The non-scientists are bound to say that the more the scientists press their claim the more rigorous will become the pruning. The fact is that the final word does not lie with the administrators but with their masters, the taxpayers. If the rate of investment in scientific research is to be significantly increased the public must expect a cut in its social services or in its private spending. The public will not be easily persuaded to do a great deal more than Whitehall already insists shall be done, unless all concerned are optimistic enough to think that people will forgo their summer holidays in the next decade so that their grandchildren can have trips to the moon. Meanwhile, the scientists and administrators would be well employed in resolving their differences of opinion.

Thin End of the Road Wedge

Nothing succeeds like success, they say. Now that the trunk road programme is well under way the road interests can be relied upon to seize every opportunity of pressing the case for an extension of the scheduled road improvement programme. It is entirely proper that they should do so—and it is equally proper that they should not be allowed to succeed to the detriment of other major capital equipment schemes. Since the road system has been neglected for two decades the best of the argument is probably with the road interests for some time to come.

An example of how the present trunk road schemes may be extended bit by bit by means of sustained pressure comes in the form of a plea from the British Road Federation that the London-Birmingham motorway should be extended to carry export traffic driving from the Midlands to Thames-side Docks. This plan has been prepared at the request of the London County Council and proposes this highway project for inclusion in the County of London Development Plan for 1961. The first priority according to the memorandum is a motorway encircling central London. Thereafter radial motorways could be built.

Lord Derwent, chairman of the B.R.F., said at the Federation's annual meeting in London last week that if Britain was to have a road system capable of carrying the traffic of 10 years hence, Government expenditure on new roads would have to be three times the peak of the present programme. Organised road opinion is evidently looking forward to a continued very high rate of expenditure on the road system in the next decade. Now that the road programme is under way they will probably get what they want though they may have to be a little more patient than their remarks would suggest that they are prepared to be.

More Steel for Canada

In the last few years there has been a marked expansion in the Canadian steel industry. By the end of 1957 the Steel Company of Canada completed its current expansion programme. Dominion Foundries and Steel have just about completed their big expansion with the installation of a final battery of coke ovens and Algoma Steel and Atlas Steel are thought to have completed their present expansion programme. In British Columbia, Western Canada Steel has doubled its capacity but this company only operates at present at an annual rate of 60,000 tons. At the turn of the year the Canadian steel industry was thought to be operating at only 70 per cent of its capacity and there is as yet no noticeable change in economic conditions in North America which would encourage any of the Canadian steel companies to devise new expansion plans.

Nevertheless the Dominion Steel and Coal Corporation is reported to have purchased 1,000 acres on the south shore of the St. Lawrence river to establish a steel mill at a cost of 20 million dol to turn out rolled products. The current capacity of Dominion Steel is about 1 million tons a year. Work on the new project is expected to start in about six months' time. Presumably the plant will be in operation about 1961 and this timing may prove to be exceedingly shrewd.

From this country's point of view one of the interesting points in this bold plan is that the Dominion Steel and Coal Corporation is a subsidiary of A. V. Roe (Canada) which is, in turn, a member of the Hawker-Siddeley Group. The new works will increase still further the dependence of the Group on the profitability of its Canadian interests.

Priority for Industrial Investment

The latest economic indicators are generally satisfactory. Industrial production taken as a whole has remained remarkably buoyant throughout the spring. There are some black patches here and there and the good performance owes much to the record output of the motor-car industry which, as always, takes a wide range of ancillary industries with it. The latest gold and dollar reserve figures are also exceedingly reassuring and the reserves are now better than they have been since 1951. The American recession now shows definite signs of flattening out, if not coming to an end, and only in the export field is disquiet being voiced by industrialists and Government spokesmen.

Greater confidence would be felt all round if it were certain that in this recession there is not an element of delayed action in the effects of the American recession. It is not inconceivable that the upswing in industrial activity in the United States, which is expected to begin in the autumn, will not be followed by a similar upswing in Europe and an expansion in world trade. Just as the countries producing primary goods have been slow to hand on the effects of

the recession on their commodities to the countries from which they buy industrial equipment, so when recovery sets in the chain reaction may be equally sluggish. The consequences of recession in some parts of the world, including this country, may be felt when the seeds of recovery have already successfully germinated in America.

The general situation is such, however, that the Government seem about to take the critical decision as to whether they can risk encouraging re-expansion in this country without jeopardising price stability. Mr. Heathcoat Amory said last week (when addressing the Association of British Chambers of Commerce) that industrial investment must have the highest priority when expansion was resumed. The interest in his remarks is not that he gave industrial expansion priority. This is inevitable because it is industrial expansion, in the sense of the output of capital goods, which has taken the brunt of the deflationary policy over the last year or two. The interest is that he chose to speak on this subject at all and to say that he was actively considering what should be done in the autumn. It is not likely, on balance, that this adds up to an autumn Budget but it may mean a further reduction in interest rates. No doubt he will wait, however, until the seasonal pressure on sterling, which has now begun and will last until the end of September, has worked itself out on the gold and dollar reserve position.

Canada's Trade Unions

In the past year the non-union activities of Mr. Beck and the well-publicised negotiations of Mr. Reuther for the United Automobile Workers have made the trade union set up in the U.S.A. well-known in this country. While everyone has heard of the merger of CIO and AFL very few people know that a similar amalgamation has taken place in Canada. On 1 May, 1956, the Trades and Labour Congress of Canada and the Canadian Congress of Labour joined to form the Canadian Labour Congress. At the beginning of last year the Congress had 171 member unions of which 111 were international unions with headquarters in the United States. At the beginning of 1957, Canadian trade unions had a total membership of 1,386,185. By far the greater number of these, over 990,000, were members of international unions. Apart from the Canadian Labour Congress there are some 99,000 trade unionists in federations organised by the Canadian and Catholic Confederation of Labour. The odd men out are the three international railway unions, with a membership of over 33,000, which are not affiliated to central bodies.

In spite of all this organisation, trade union members represented only 32·8 per cent of the total of Canada's non-agricultural workers. In manufacturing industry some 40 per cent of the workers are organised. The trade unions have made their biggest advances in the service industries where the labour force has gone up by 30 per cent in the last eight years, and one man in six is now a union member.

According to the *Ministry of Labour Gazette* more than 30 per cent of the workers had a standard working week of 40 hours or less and nine-tenths of them had a five-day week. Some 95 per cent of the 6,000 firms questioned gave their workers two weeks' annual paid holiday. Only those with 15 years' service qualified for a third week's leave. The number of firms with pension plans, group life-insurances and sickness benefits has risen steadily in the past four years. By April, 1957, nearly 88 per cent of factory workers were with firms running hospital schemes which included arrangements covering surgeons fees. In organisation and objectives the pattern of trade union development in Canada is very much more like that of the United States than of Britain. In the recent elections some unions supported socialist candidates, most of whom went down in the Diefenbaker landslide. Now the unions are waiting to see whether American model legislation in the shape of a Canadian Taft-Hartley Act will complete the analogy with practices south of the border.

Waiting for De Gaulle

Ever since the war the efforts of French business men have been nullified by feeble central government. In spite of the ham-handedness of the politicians of the Fourth Republic, however, the French industry has some great achievements to its credit. The railways are now technically as good as any in the world. The Caravelle looks like being one of the outstanding aircraft of the next decade. And on a smaller scale the motor industry has produced two big sellers in the Dauphine and the Simca " Aronde," the former outselling every foreign make in the American market except the Volkswagen. The immediate effect of General de Gaulle's emergence as Prime Minister has been a general improvement in confidence, reflected in the best looking franc for some time. The April index of industrial production, the timing of which was most convenient for the new Government, showed production five points up on the previous month and 17 points on a year ago. The biggest gains were in engineering and building materials. Unemployment is now around the 100,000 but one-third of these are said to be over 60 years old.

But although the French economy is fundamentally strong enough eventually to overcome all its difficulties, the immediate future is none too bright. The EPU (European Payments Union) Agreement comes up for renewal at the end of this month. The position is complicated by the fact that the Common Market tariff cuts are due on 1 January, after which date EPU in its present form will not be entirely appropriate.

M. Pinay, France's new Finance Minister, has said that he does not think France will be able to fulfil her Common Market obligations " completely." This can only mean that neither quotas nor tariffs will be eased. The negotiations for a free trade area presumably now come to a halt with the prospect of starting up again in the new year. But it looks as though freer trade and payments arrangements in Western Europe must wait on General de Gaulle.

Engineering in Western Europe

The engineering industries defy clear definition, shading into the steel industry at one end, consumer goods at the other and mingling with a host of others in between. While producing one-twelfth of Western Europe's income, engineering consumes one-sixth of its steel. It employs over 4 million people, some 3 per cent of the active working population of the OEEC countries. In some countries this percentage is much higher. In Britain it is 7½ per cent, in Germany 7 per cent and the two together account for two-thirds of total engineering employment in Western Europe. In 1956, OEEC countries exported £1,204 million worth of engineering goods to the rest of the world, and £987 million to other member countries. Imports from the outside world were only £261 million mostly from the United States. The United Kingdom is the largest exporter of heavy electrical machinery, followed by Germany and then, well behind, France, Belgium, Sweden, Italy and Switzerland. The provision of nuclear power will make great demands on this section. The proposed Euratom target of 15,000 MW capacity by 1967 is estimated to require £1,875 million worth of plant, mostly to be supplied by Great Britain or the United States.

These are the conclusions of an article in last month's issue of *Steel Review*. The writer believes that if incomes are to rise, investments and therefore demand for engineering goods must increase. While there is no cause for over-optimism, the prospects for the engineering industry both in Europe and world markets are put at " generally very good."

Letters to the Editor

COUNTING WITH THE FINGERS

SIR, Electronic calculating machines work on the *binary* system of calculation as against the *decimal* system. By using the same method for counting with the 10 fingers of his two hands, a man can go as far as 1,023.

The underlying theory is that all numbers can be written as the sum of integral powers of 2. including zero. For example,

$$13 = 1 + 4 + 8 = 2^0 + 2^2 + 2^3$$

or, $$873 = 1 + 8 + 32 + 64 + 256 + 512$$
$$= 2^0 + 2^3 + 2^5 + 2^6 + 2^8 + 2^9.$$

It should be noted here that there is only one way of doing this, i.e., no second combination of

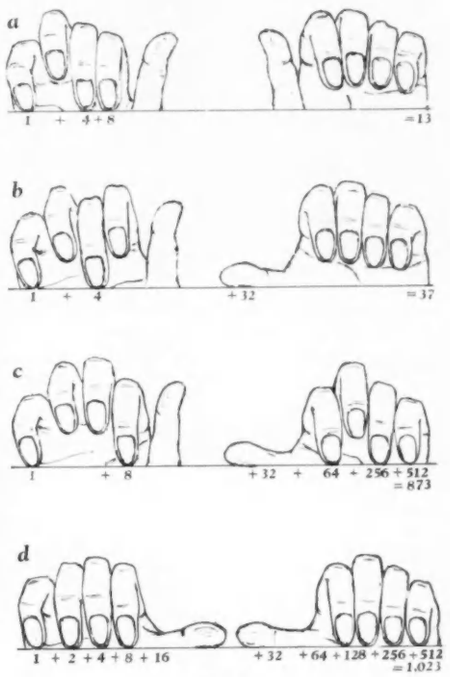


Fig. 1

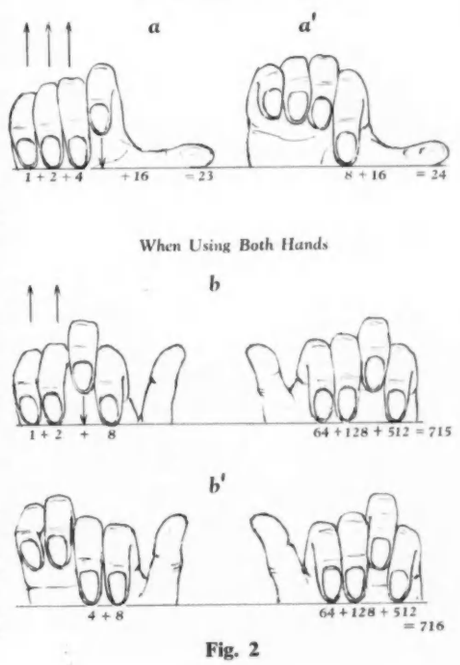


Fig. 2

Continuing Letters to the Editor

powers of 2 can give the same number. Now, instead of denoting the numbers, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 by the 10 fingers, let us denote the indices 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 in, for example, the following order:

Right Hand		Left Hand	
Little finger	$2^0 = 1$	Little finger	$2^5 = 32$
Ring finger	$2^1 = 2$	Ring finger	$2^6 = 64$
Middle finger	$2^2 = 4$	Middle finger	$2^7 = 128$
Fore finger	$2^3 = 8$	Fore finger	$2^8 = 256$
Thumb	$2^4 = 16$	Thumb	$2^9 = 512$

We can then count numbers up to 1,023 by putting down fingers, as shown in Fig. 1, for 13, 37, 873, and 1,023.

In the following table, x indicates the fingers to be put down for counting any number up to 31 on one (right) hand only. The process can be continued in a similar way with the other (left) hand to count up to 1,023.

From the foregoing, it will be seen that to increase a number by 1, all that is required is to lower the first raised finger (counting from the right) and, at the same time, to raise all the fingers to the right of the finger whose position has been changed. This action is illustrated by Fig. 2 for $23 + 1 = 24$ (using the right hand only); and for $715 + 1 = 716$ (using both hands.

Counting with right hand only

Number	(1) Little finger	(2) Ring finger	(4) Middle finger	(8) Fore finger	(16) Thumb
1	x	·	·	·	·
2	·	x	·	·	·
3	x	x	·	·	·
4	·	·	x	·	·
5	x	·	x	·	·
6	·	x	x	·	·
7	x	x	x	·	·
8	·	·	·	x	·
9	x	·	·	x	·
10	·	x	·	x	·
11	x	x	·	x	·
12	·	·	x	x	·
13	x	·	x	x	·
14	·	x	x	x	·
15	x	x	x	x	·
16	·	·	·	·	x
17	x	·	·	·	x
18	·	x	·	·	x
19	x	x	·	·	x
20	·	·	x	·	x
21	x	·	x	·	x
22	·	x	x	·	x
23	x	x	x	·	x
24	·	·	·	x	x
25	x	·	·	x	x
26	·	x	·	x	x
27	x	x	·	x	x
28	·	·	x	x	x
29	x	·	x	x	x
30	·	x	x	x	x
31	x	x	x	x	x

I should like to acknowledge the help given by Fröken Irina Hoffman in preparing this letter.

Yours faithfully,

M. P. Varshney,

Indian Institute of Technology,
Kharagpur,
West Bengal, India.
17 May, 1958.

TURRET TUNER PLASTICS

Sir, With reference to the article under the above heading, on p. 704 of your issue of 30 May, may we draw your attention to our name being given incorrectly as A. *E.* Metal Products Limited, whereas it should be A. B. Metal Products Limited.

Yours faithfully,

Henry J. Kroch,
Works Director.

A. B. Metal Products Limited,
Abercynon, Glamorgan.
3 June, 1958.

Plant and Equipment

TRACTORS IN THE ANTARCTIC

The valuable services rendered by British farm tractors to the Commonwealth Antarctic Expedition led by Sir Vivian Fuchs, have been a source of pride and gratification to the makers in this country. Speaking in London recently, the Expedition's chief engineer, Mr. David Pratt, gave some details of the way in which the expedition had made use of their seven 32 b.h.p. Massey-Ferguson TE 20 tractors. Five of these machines were operated by Sir Edmund Hillary's party at Scott Base and two were stationed at Shackleton base for Sir Vivian's party. Petrol-engined versions were preferred for this expedition mainly for two reasons—their easier startability and their greater familiarity to most members of the expedition, any one of whom might be called upon to drive and service a vehicle at times.

To fit the Ferguson tractors for antarctic service, the principal modifications consisted in the fitting of full-track tyres, the provision of silicone rubber insulation for the electrical system, the installation of larger batteries and starter motors, and the sealing of the brakes against water entry. Low temperature lubricants and hydraulic fluids were, naturally, adopted and the engine coolant was a Kilfrost fluid capable of resisting some 90° of frost. To aid in engine starting—which could be reliably carried out by hand—preheating systems were used.

Hillary's tractors, which were used for base construction work under particularly rigorous conditions—severe snow blizzards and extreme cold—were fitted with a plywood cab for protection and had a rear power take-off. The tyres of these tractors were provided with additional lugs to improve their traction on soft snow—conditions in which the Ferguson tractors, unlike the much larger Sno-Cats, were less at home than on hard snow, which they liked very much. A rigid schedule of preventive maintenance was one of the factors contributing to the success of the operations.

The various duties for which the low-powered, lightweight "Fergies" were chosen were base uses—assisting in building operations, snow digging (using high-lift loaders) and load-hauling over distances of up to 300 miles or so. Weighing only a ton, they tackled crevasses with great success. For the long hauls over altitudes ranging from 9,000 to 11,000 ft, the higher-powered Weasels and Sno-Cats were the natural choice. Nevertheless, three of Sir Edmund Hillary's Fergusons acquitted themselves with commendable freedom from mechanical trouble, on his 1,200 mile dash to the South Pole—and there they are still in use, now with the U.S. Navy Department, operating each day "for periods of half an hour at a time at temperatures between 80° and 90° below zero."

3 TON PNEUMATIC WINCH

A very large pneumatic winch has recently been built by the Globe Pneumatic Engineering Company Limited, Romford, Essex. Powered by the latest Globe 10 h.p. radial air motor No. 6, the winch has a safe lifting capacity of 3 tons. Its average rate of lift is 50 ft per min and its rope drum takes 1,000 ft of $\frac{3}{4}$ in dia. wire.

The winch has been developed for use in larger construction projects, nuclear power stations and general steel erection. It has the advantage of totally enclosed engine and gear cases, making it completely weatherproof. Other features include an automatic brake. The No. 6 air motor has five cylinders and will deliver 10 h.p. at 600 r.p.m. at air pressures between 80 and 100 lb per sq. in; its diameter over the radially mounted pistons is $18\frac{1}{4}$ in and its overall length without driving shaft is $15\frac{5}{8}$ in.

The direction of the motor rotation can be changed by reversing the air flow, and the motor is capable of an infinitely variable speed. It cannot be damaged by overloading or stalling and is unaffected by corrosive or damp atmospheres.

In design, particular attention has been paid to the total sealing and pressurising of the crankcase in order to obviate lubricant losses. A needle roller big end is employed and ball bearing mountings for the crankshaft. Available for either flange or base mounting, the motor can also be fitted with an integral throttle reversing valve of high sensitivity.

ELECTRONIC DEVICES IN MANCHESTER

Arrangements have been made by the Northern Division of the Institution of Electronics to hold their annual exhibition and convention—the thirteenth of the series—at the College of Science and Technology, Manchester, from 10 to 16 July. This year's very comprehensive display of electronic apparatus will include examples of the products of some 75 manufacturers from Britain, the Continent and the United States. There will also be a scientific and industrial research section, to which contributions will be made by Admiralty research and training establishments, the National Coal Board, the British Rayon Research Association, and the radio department of the Lancashire Constabulary. Lectures and films will cover such topics as "A Pulse-Operating Valve Characteristic Analyser," "The Manufacture of Tektronix Special-Purpose Cathode-Ray Tubes" and "Electronic Techniques Applied to the Developing and Processing of Man-Made Fibres."

Admission to the convention will be by ticket, obtainable free of charge from the Institution's honorary general secretary, Mr. W. Birtwistle, 78 Shaw Road, Rochdale, Lancs. Catalogues, price 2*s.* 9*d.*, will also be obtainable from Mr. Birtwistle after 1 July.

REVERSING STARTERS

A range of direct-to-line reversing starters, incorporating vertical-lift contactors similar to those in the company's XB and XC non-reversing types, has been introduced by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, for starting motors of from 1 h.p. to $12\frac{1}{2}$ h.p. The four-pole forward and reverse contactors are interlocked mechanically so that when either is closed the other is locked open, and there is a further electrical interlock through side switches operating in conjunction with each contactor, which prevents the two operating coils from being energised together. Additional side switches for controlling associated circuits can be fitted if required. The triple-pole overload units have adjustable oil dashpot time lags.

Any starter can be supplied with a cam-operated double-break, triple-pole interruptor switch capable of breaking the stalled motor current. The 10 h.p. and $12\frac{1}{2}$ h.p. sizes have a plug-in mounting which permits removal without disturbing incoming and outgoing cables. "Forward," "Reverse" and "Stop/Reset" buttons are mounted on the case for local control, or motors may be controlled remotely by push-buttons or pilot switch. An ammeter can be fitted on top of the case if required, and accommodation for control fuses is available inside the starter.

Continuing **Plant and Equipment**

AUTOMATIC SCRAP CUTTING

Arrangements have been made for the production in Great Britain of an American 600 ton automatic hydraulic scrap cutting shear believed to be the only machine of its type and size. Designed by the Clearing Machine Corporation, Chicago, Illinois, the first machine is now under test in the United States. As is the case with other Clearing presses made in this country, manufacturing will be undertaken by Vickers-Armstrongs (Engineers) Limited, Newcastle upon Tyne, and selling will be handled by the Rockwell Machine Tool Company Limited, Welsh Harp, Edgware Road, London, N.W.2.

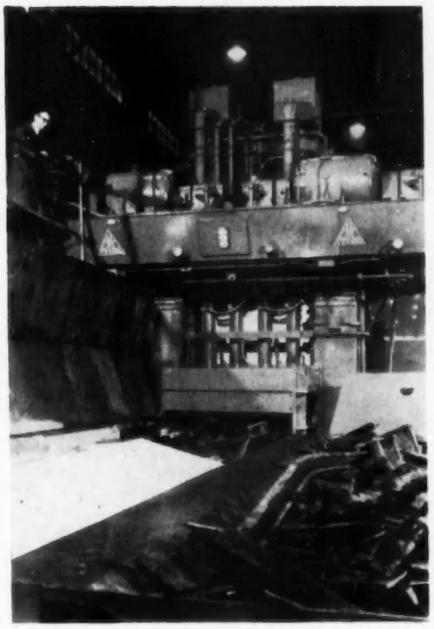
Designed for use in the open, with its operating mechanism totally enclosed and weather-proofed, the shear will cut almost any kind of mixed scrap, loaded by magnet crane, into equal lengths, adjustable in 6 in increments from 6 to 48 in. It will cut up to 30 tons an hour.

At the rear of the press is a hydraulically-tilted hopper and a feed box which houses the hydraulic ram that feeds scrap to the adjustable shear blades.

As soon as the shear hopper has been filled with scrap by the magnet crane, the operator presses the " start " button, and the automatic cycle commences. The hopper is raised hydraulically to dump the contents in the shear feed box, the box lid closes with a pressure of 95 tons, and the hopper returns to its original position. A hydraulic ram in the feed box then moves forward a pre-set distance equal to the length of cut required, pushing the scrap under the shear blades. A 100 ton multiple hold-down keeps the scrap firmly in place, and the shear slide then makes its stroke. Finally, the shear slide rises, hold-down pressure is released, and the ram moves forward again to start another cycle. Operation continues automatically until all the scrap in the feed box has been sheared. While the shear is operating the loading hopper is re-filled by the crane, and operation is thus virtually continuous. Sheared scrap can be removed by magnet crane, by conveyor, or by other means according to requirements.

Fully-automatic speed control makes the best possible use of the time cycle. At the start of the cycle the shear moves at 510 in/min until a pressure of 70 tons is reached, then it reduces speed to 255 in/min until 180 tons pressure is registered, when the final travel rate, 85 in/min, comes into operation; this rate continues right up to the maximum pressure of 600 tons. Quick return after shearing is at 510 in/min. Manual control by push-button can be engaged by means of a selector switch for setting purposes.

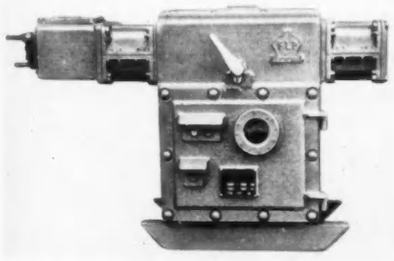
Total operation time depends, of course, on the work the shear is doing, but taking an 18 in cutting length, with a 4 in intermediate pressure requirement of 180 tons, and a 2 in pressure requirement of 600 tons, the cycle time will be 12 seconds. On such a typical job, therefore, the press will complete five cycles a minute, and will shear a full feed box load in three minutes.



Up to 30 tons of random scrap can be cut into lengths of from 6 in to 48 in by the Clearing automatic cycle hydraulic shear.

MOTOR STARTER *For Small Motors in Dangerous Sites*

The Nelbest DDOF/30 is a starter for small horse-power squirrel-cage motors in such applications as the mining, chemical and oil industries. The complete unit has been certified for use with groups I and II gases and measures 25½ in by 20 in by 20¾ in deep without the cable boxes. The top chamber contains a triple-pole isolating switch mounted on straight-through busbars. The end connecting plates are made to N.C.B. specification. The incoming cable boxes can be arranged for sealing chambers and trifurcating boxes, or, alternatively, for a flit-plug system. Single-phase protection is provided by overloads of either the magnetic or thermal type. Inside the main chamber are high-rupturing-capacity fuses which are accessible when the front cover is open. In addition the switch can be fitted for remote control with a low-voltage transformer and there is provision for an ammeter if desired. The makers are W. and H. Nelson Limited, Nelbest Works, Mossend, Lanarkshire.



Flame-proof starter for small squirrel-cage motors.

COMPRESSED AIR

A film has been produced by the Maxam division of the Holman Group describing the uses of some of their compressed air control equipment. After an introduction showing the manufacture of the items, there follows a long list of examples of the units in action as clamps or motion controllers in machine tools, and as actual tools such as broaches and presses. The film stresses the possibilities of automatic operation.

The 16 mm film, which is titled " A Measure of Maxam," is in colour and sound; it runs for about 20 minutes and can be borrowed from the Climax Rock Drill and Engineering Works Limited, 4 Broad Street Place, London, E.C.2.

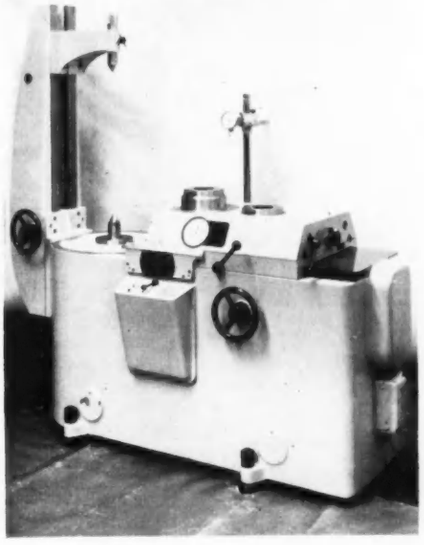
ROLLING GEAR TESTER

The No. 4 rolling gear tester that was exhibited at the Gauge and Tool Exhibition by J. Goulder and Sons Limited, Kirkheaton, Huddersfield, is intended for large gears of all types and the proportions have been fixed with the heavy weights of large gears in mind. It has a capacity up to 32 in between centres giving a maximum gear size of about 4 ft diameter, and attachments are available for shaft gears up to 32 in long and 20 in diameter, worms and wheels, bevel gears and internal gears. A power-operated rotary table is also available.

The variations in centre distance are read from a 4 in diameter dial gauge placed in front of the floating saddle. It is possible to fit an electrical recording apparatus which gives magnifications of between 100 and 5,000 times, giving permanent records of gears checked. The nominal centre distance is set by means of a vernier and scale.

The sensitive saddle is mounted on precision balls. The saddles may be hand or power driven in any direction and are controlled either from the hand wheel in the front of the bed or by the lever on the control panel. The sensitive saddle is spring-urged forward (or backward in the case of internal gears) by means of spring pressure which may be set at any value up to 20 lb. The sensitive saddle may be lifted off its tracks by means of a cam and lever at the right of the saddle. This prevents damage when loading heavy gears. The slideways are completely covered by a rigid plate to prevent damage.

All castings are of Meehanite carefully selected and seasoned. The steels are nitriding or nickel hardening. The tester is supported on three feet, the best theoretical mounting, but is also provided with two other feet for additional stability. Lifting holes are provided in the main casting. The approximate size is 60 in by 24 in by 32 in and the net weight is 2,000 lb.



Gears up to 4 ft diameter can be accommodated on this rolling tester.

Continuing **Plant and Equipment**

PRECISION BORING, GRINDING AND MEASURING

A compound worktable, with settings by optical co-ordinates, is the basis of the Deckel jig boring, grinding and measuring machine, made by Friedrich Deckel, München 25, Germany, and marketed in this country by Burton Griffiths and Company Limited, Kitts Green, Birmingham, 33.

Carried on a heavy cast iron base, with bellows-protected guideways, the worktable is 25·6 in long and 11·8 in wide, and has push-button controlled rapid power traverse, with rough setting scales graduated to English or Metric standards as required. Table adjustment is continued by means of handwheels and is completed by sensitive knobs, in conjunction with the optical co-ordinate system. The range of co-ordinate settings is 15·75 in by 10 in, and the readings, which are taken from a magnified and illuminated image on a glass screen, are accurate to 0·0001 in without the necessity for estimation. It is possible for a skilled operator to observe deviation of as little as 0·00004 in from the desired position of the table.

BORING

Long slideways at the rear of the machine base carry a vertically adjustable gearbox, which provides the drive for the boring or grinding head. Compensating gear is built into the gearbox to overcome the effects of thermal expansion, and so preserve the accuracy of the tool spindle relative to the work as machine or room temperatures increase. On the top of the gearbox is a mounting bracket to which can be attached the boring, grinding or measuring head.

The boring head has a swivelling housing, which enables it to be turned through 90° in either direction in a vertical plane, and is adjustable over a range of 4 in vertically. Twenty speeds, from 40 to 3,150 r.p.m., are available for the boring spindle, and there are six feed rates, which can be used with any spindle speed, upwards or downwards.

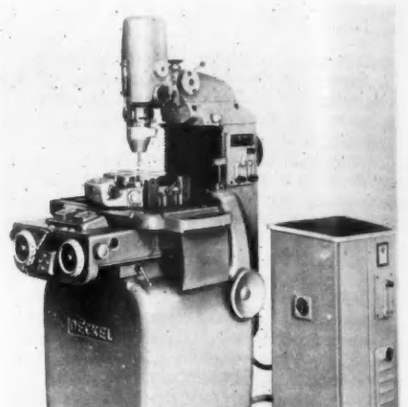
GRINDING

The grinding head can be swivelled through 45° either side of the vertical, and has a planetary-motion spindle which traverses the grinding wheel in a circular path while it is rotated about its own centre in the normal way. A range of diameters from 0·031 in to 4·9 in can be covered by the planetary movement of the wheel. There are 12 planetary speeds, and an automatic vertical oscillating motion of the wheel ranging from $\frac{5}{32}$ in to $3\frac{1}{8}$ in. Taper as well as parallel bores can be ground. The grinding spindle speed range is from 15,000 to 60,000 r.p.m., control being by means of a frequency changer.

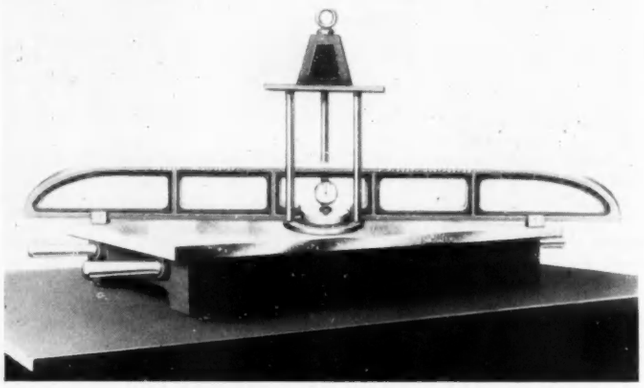
MEASURING

An optical projector can be mounted on the gearbox bracket of the machine in place of either the boring or the grinding unit. There are two magnifications, ×10 and ×20, and the head has a screen $7\frac{7}{8}$ in diameter, rotatable through 360°. The head can be tilted to 15° on either side of the vertical.

Numerous extra fittings are available for use with the three heads. They include an optically-adjusted circular table, with readings to one second of arc, an extension unit to enable the machine to deal with large workpieces, a machine vice, equipment for accurate centring of the work, and a dust-extraction system. A ground plane-glass measuring table, and brackets for cylindrical and tapered work are available for use when the machine is fitted with the measuring head.



Jig boring, grinding and measuring by optical projector are possible on the interchangeable-head Deckel machine. As shown here, the machine is equipped for grinding.



Deflections of the surface plate under load can be measured by beam and dial indicator.

SURFACE PLATE DEFLECTIONS

The deflection of surface plates and tables when subjected to a load can make a great variation to resultant gauge readings or accuracy checks. For instance, when checking the accuracy of articles using a cylindrical square on a surface table, it is possible that the deflection caused to the table by the weight of the cylindrical square will make all the subsequent inspections untrue, and unless the deflection is limited to a predetermined figure, or is known, all inspections can vary according to the weight of the gauges, etc., used.

The revised B.S.817/1957 brings the existence of this "weight deflection" to the fore and fixes a maximum deflection under load for the various sizes of surface plates and tables from 14 in by 10 in upwards, both in cast iron and granite, and the NPL have recommended a method of checking the amount of the deflection.

It is to meet this recommendation, and to provide a ready means for users to check their own equipment, that Rubert and Company Limited, Chapel Street, Stockport Road, Levenshulme, Manchester 19, have designed and produced the equipment shown in the illustration.

This equipment consists of (*a*) a rigid aluminium beam which is supported at each end by two adjustable feet, and incorporates a sensitive dial indicator (a third adjustable foot is positioned centrally along the beam, but slightly off-set, to keep the beam stable), and (*b*) a central weight support comprising a platform for the requisite number of weights, mounted independently of the beam, on a ring, which permits the plunger of the dial indicator to press against the plate under test.

Not only can surface plates be tested for conformity to B.S.817/1957, clauses 7a and 17a, but the inaccuracy due to deflection, under a given load, of plates and tables already in use, can be precisely assessed, and compensated for in ultimate calculations. The beam itself can also be used as a beam comparator in which case, of course, the third foot is not used. The equipment is made in three standard sizes: 3 ft, 6 ft and 10 ft long.

INTERNAL INSPECTION

An instrument designed for the inspection of internal surfaces is the Inspectascope now being made by Vision Engineering Limited, Send Road, Send, Woking, Surrey. It is virtually a periscope with a built-in lighting system. At the end of the tube is a mirror (which can be removed for direct vision), and a bulb fitted on the side gives a co-axial light beam for illuminating the work. In the smaller sizes the reflector is of chromium and all tubes are of steel. The battery-operated lamps are mounted in a shock-proof housing. The eyepiece has a rubber guard and contains the magnification lens, which is thus kept away from the workpiece and possible damage. There are no lenses mounted in the tube.

A wide range is available from $\frac{1}{8}$ in to $1\frac{1}{2}$ in outside diameter and with extension pieces up to 40 in long. There is one version for large area inspection and another with non-conducting probes for working among live wires.

INDUSTRIAL USES FOR PAPER TOWELS

Hi-Dri paper towelling, now a familiar sight in the washrooms of industrial concerns and other organisations, is being increasingly used in place of cleaning rags in engineering shops for reasons of hygiene and convenience. Its qualities of immediate absorbency and high wet strength render it most suitable for removing excess oil from delicate components and for washing down plant. In the printing industry it is preferred to rags for wiping down highly-finished printing rollers, and glass plates used in photographic processes, because it does not lint or fluff. It is available in roll form, 9 in or 18 in wide and 250 ft long, or as individual folded towels; the makers supply and install dispensing cabinets free, on loan.

Hi-Dri paper towelling is made by the Industrial Division of Kimberly-Clark Limited, 11 Grosvenor Gardens, London, S.W.1.

Companies in the News

G.K.N. Expansion

The Guest, Keen and Nettlefolds group of companies last year produced 1·3 million tons of steel of which 945,000 tons was processed within the group. Trading profits were £2¼ million higher at £23·95 million. These results, explained Mr. K. S. Peacock, chairman of the group, benefited "from the heavy capital expenditure of earlier years and from increased turnover, although profit margins have continued to contract." Some £12·8 million was spent on capital account during 1957 and as much as £33 million of expenditure had been sanctioned and was outstanding at the end of the year.

Mr. Peacock was neither optimistic nor pessimistic concerning the immediate future. He noted that "current economic conditions, particularly in the United States, are unfavourable" and that he expected this to affect the group's trading. Like most large firms they had experienced better conditions in the early months of this year than had been expected, but there is nonetheless "a weakening tendency generally, some companies drawing on their order books [so that] in the main the rate of ordering is on the decline." An interesting point made by Mr. Peacock was that the considerable expansion of productive capacity within the group made it less necessary for customers to order a long way ahead. Presumably the same applies over a wide field of engineering and some of the disparity between the inflow of orders and production could be due to the shortening of the pipeline.

The G.K.N. Group comprises 83 companies of which 55 are located in the United Kingdom and 28 overseas, which together produce a very wide range of end products—including, for example, automatic vending machines, heat exchangers, machine tools and domestic washing machines. Such diversity lends special weight to their assessment of the basic trends affecting the engineering industry. The fact that they are spending at the rate of some £8 million to £10 million a year on new plant and equipment is a measure of confidence in their long-term prospects from which many will draw comfort.

Outlook for Gears

Manufacturers of gears are having to fight much harder for business and are beginning to feel a slight draught, particularly from the commercial vehicle field. E.N.V. Engineering Company Limited, who are one of the major companies in the business, reported that although the passenger car trade is busy, the commercial vehicle trade "has been and is still quiet," with the result that their sales of gears and components in that field were "on a considerably reduced scale." Exports, on the other hand, were a record and continue to increase—a sign perhaps of the growth in the local manufacture in underdeveloped countries of commercial vehicles as well as machinery and plant. E.N.V.'s turnover from industrial gears continued to be satisfactory, but this is a relatively small part of their business and there is little doubt that the company could do with more work. Their chairman, Mr. C. G. Twallin, summarises the situation most aptly as follows: "We still have an impressive order book but incoming orders are not of the same magnitude as those we have been receiving in past years and reflect a more cautious approach on the part of our customers." They are therefore constantly seeking "to broaden the basis of their business" and have recently acquired the business of H. Williams and Sons of St. Albans and of their subsidiary, Industrial Descaling Tools.

Companies less dependent on the automotive industry for their business have done relatively much better. Henry Simon's Turbine Gears, for example—who design and manufacture gears and gear units for all fields of industry, specialising in single and double-helical gears—have done well in 1957 and, according to the group's chairman, "enquiries, orders and deliveries continued at a high level." Opperman Gears (Holdings) who also concentrate in the field of industrial gearing and medium to heavy engineering, have increased their turnover, though profits were down by £10,000 to £62,315. Their chairman, Mr. W. B. McCurd, reported that they started 1958 with a record order book and that during the first three months of the year sales were appreciably higher than in the first quarter of 1957. But, he added, "whilst we are optimistic, trading conditions are extremely difficult, margins are being reduced and competition is daily becoming ever keener both at home and abroad." This would seem to be a fairly general feeling in the industry.

N. V. Philips of Eindhoven

The phenomenal rise of the N.V. Philips group since the war as an international power in electrical engineering entitles them to respect for their views. No company in the western hemisphere has surpassed their rate of growth and few have equalled it. In 1950 their turnover totalled 982 million guilders; in 1957 it passed the 3,000 million mark. The lowest increase registered during that period was one of 11 per cent in 1952 (when the sales of most other companies declined) and the highest one of 26 per cent, in 1951. Last year sales rose by 18 per cent. Profits before tax during the same period rose by 26 per cent, from 313 million guilders to 393 million.

The keys to the group's success are stated quite simply as "scientific research, development and mechanisation." Scientific research, they say, is quite indispensable to fulfill the conditions for a further reduction in costs and to broaden the basis for initiating new ventures, which are "both equally desirable from the point of view of profits and earning capacity." Philips' success therefore depends on making the right products as efficiently as the latest techniques and equipment will permit. The fact that their expansion has "scarcely suffered any adverse effects from the gradual slowing down of the world's economy" is attributed to a great diversity of products providing self-compensating outlets and to a policy of keeping prices steady and as low as possible.

There is a great deal in this report which is of vital concern to electrical engineers and businessmen. It lends strong support to the view that the future is brightest for the largest companies, financially very strong and able to attract the necessary risk capital to forge ahead in what many would call the unknown. Also to the view that a wide diversity of production is required to achieve stability. Philips' "tempered optimism" springs from the conviction that "notwithstanding the less favourable trend which the world economy is expected to take, the products of the electrical engineering and electronics industries will continue to gain in importance in modern society." Their stake is in man's procreative instinct and in his wish to improve his lot—both rather basic and powerful.

Too Much Cable Capacity ?

The poor results of several of the larger electric cable manufacturing concerns in the past two to three years had given rise to some comment about "concentration" of the industry. While it may well be that there are too many workers—from the point of view of maintaining an adequate level of research and development—it is unlikely that the total production capacity is excessive. Traditionally the industry operates on a relatively short-term order book and manufacturers have therefore never had the "security" of several years' orders on hand. In recent months the situation appears to have improved somewhat.

The annual statements of two companies in the industry, British Insulated Callender's Cables, and Johnson and Phillips, have been published. The chairman of the latter, Mr. William Glass, told shareholders that "there are no signs that the severe competition . . . is likely to lessen and profit margins are very small." The possible integration with W. T. Henley's Telegraph Works Company now being examined by the boards of both companies is the first of several likely mergers in the industry. The fact that Johnson & Phillips should have averaged only £364,000 of trading profits in the past two years on capital and reserves of over £5 million is a clear enough indication that the present position is not satisfactory.

B.I.C.C. have also experienced difficulties during 1957. Their profits fell by £1·6 million to £7·8 million. In his review of trading conditions in the cable industry, their chairman, Mr. W. H. McFadzean, said that although no-one doubted that the world demand for electricity must be upward, "requiring more and more cable," shortages of capital and restrictions of purchasing power led one to question "whether from the short-term aspect there is not some surplus capacity existing for certain products of the cable industry." Confidence in the medium and long-term aspects, which he expressed, does not solve to-day's problem of increasing competition and falling profit margins.

"Fossets"

A company deservedly in the news is Fawcett Preston and Company Limited. This lively firm (they have been a member of the Metal Industries Group since 1948) are celebrating their 200th anniversary—and doing it admirably too. The exhibition of records of the company which has been staged at their works at Bromborough, Cheshire, is a model of painstaking research and imaginative presentation. It remains open until the end of the month, and there is a possibility that it may be moved for a run at Liverpool, where the firm had their works until they moved in 1936. For those who cannot visit the exhibition there is the chance of seeing a copy of "*Fossets": A record of two centuries of engineering*, which is no mere publicity pamphlet but a history that would do credit to the Newcomen Society for the Study of the History of Engineering and Technology. Mr. Horace White, who produced the book and the exhibition, has thereby done a great service in assuring the employees of "Fossets" that, although they are now members of that modern organisational development the Group, their separate identity and their unique traditions and history are cherished and proudly extolled.

The company's chief products to-day are a range of baling presses, special purpose presses, machines for covering wire and cable with rubber or plastics, steel fabrications, and electrical resistors. They have always been ready to undertake new production jobs—which is perhaps why they have lived to celebrate their bi-centenary. In 1758, they started in business with a depot for the distribution of "three-legged iron pots." But they turned to making cannon, steam engines, the first marine engine to be built on Merseyside, engines for the first P. & O. steamer, the "William Fawcett" (which was named after the man who directed the company for 60 years), and later to hydraulic and screw presses, sugar machinery, gun carriages and ammunition wagons, a steam motor-car, and sea-water distillation plants.

Sir Charles Westlake, chairman of Metal Industries and Fawcett Preston, said at a bi-centenary luncheon last week that the company had always been concerned more with people than with profits. "If all of us genuinely believed in that and acted accordingly," he said, "then peace in industry, from being a hopeful phrase, would become an assured reality." Certainly, in looking back on 200 years of engineering, it is the people and not the profits that one thinks of.

Talking to Americans

AMERICA IS STILL GOING PLACES

United States readjustment to changing patterns in national and international affairs is the subject of a series of articles in ENGINEERING. Following a visit to the Soviet Union last year, Mr. E. P. Ward, a deputy editor of the journal, has recently completed a tour of the United States, where he talked with business men, company executives, engineers, research personnel, university staffs and many other people. In the present series of articles he seeks first of all to give an impression of the country and the present situation there, and then to examine the directions in which current thinking seems to lead. Last week he introduced the series by discussing his journey, its purpose and the people whom he met, under the title I Like Americans. This week, following a sketch of life in the United States, he looks at the economic situation. America is Still Going Places is in four sections: The Territories, (and in later issues) The Trails, The Frontiers and Beyond the Frontiers.

THE TERRITORIES

THE United States cannot be characterised in a few words. An impression gathered from *Time* magazine differs markedly from the images created by television and the cinema, or by the outrageous parody of *Mad*. Most of us feel we know what is meant by the American Way of Life, but if we are fortunate enough to visit the United States we discover that our preconceptions only partly represent the truth. Since to understand any change, it is necessary to know what is changing, I have recorded some brief impressions of the American scene. The major part of the article is a consideration of the recession.

Way of Living

America is more than anything a language, a way of talking that leads to a way of thinking. On to English have been grafted elements of other languages, and the result transformed by the traditions of wise-cracking and advertising. " Rides like a lullaby, sells for a song," musically claims a Ford poster. " Don't get too enthusiastic " advises a pasteboard card in a research laboratory. " This is a non-profit organisation; we didn't plan it that way, but it is," wryly comments another in the office of a university department. " Have wife and child " warns a scrawled notice on the back of a truck. " If we can't fix it, throw it away," suggests a jeweller's advertisement. " You want the eighth floor? Sure, I'm going that way," says the elevator man. If language is the lubricant of thought then the Americans have developed a low-viscosity grade.

In America, one may see a man walking in the street listening to baseball scores on a transistor radio, or a nun driving her companions on a sight-seeing tour in an orange and chromium De Soto. Indeed engineering is so taken for granted that nature itself is sometimes superseded, and a landscape may be billed as " photogenic." It is a land where an elderly negress living in a country cottage may have a deep freeze and a Plymouth, and many families run second and third cars.

America is a place in the desert where you can buy Pepsi Cola; where the beer is always iced and where the short brusque answer is meant with no ill-feeling; where " colonial " is a U-word and Mothers' Day lasts a fortnight; where " togetherness," " fun," " fancy " and " air conditioning " are words to sell a product or a service, and where each man knows the room temperature that he prefers. In America you can take a high-school course in graceful living, use an adding machine to help you with your prep, or drive to school by car as soon as you are 12—so long as you can quote a proper reason. Your newspaper may have a hundred pages, often in colour, and the sport and financial sections may sometimes be combined.

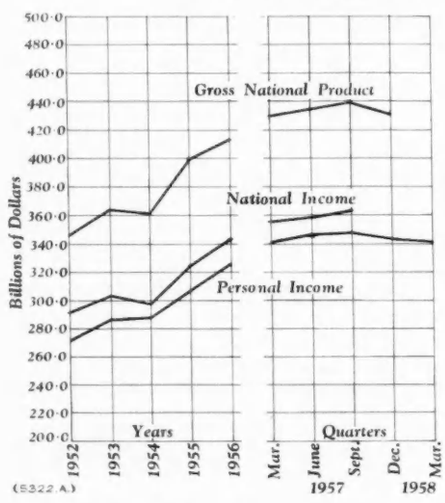
America is where your food is likely to be precooked, vitaminised and elaborately packaged, and where hot soup and magazines may be bought from slot machines; where you can buy a portrait record of Mrs. Roosevelt, or a picture in sound of the signing of Magna Carta; and where a professor of Romance languages may be interested in radar. It is where a trade-union commercial may come between Miss Fitzgerald and Mr. Presley, and the viewer has eight channels from which to choose. In a single programme, television give-aways may include a speedboat, a Ford car, a Roman chariot, jewellery, a grand piano and an aviary; but the list price for an automobile may not include a coat of paint. America is where a man from Kansas City—" gone about as far as they can go "—may still be awed on a visit to New York; where sad and lonely pickets parade in front of barbers' shops; and where office desks may bear the warning " Think." America is where daylight-saving time and speed limits vary from state to state, and where you pay for the use of a good road or a tunnel. It is where advertising gives the visitor his first impression, and where selling goods seems to be a more important task than making them.

Advertising, so strong an influence in American life, has its own locale—Madison Avenue—as we have Savile Row for tailors. The principal and most valid defence of its excesses is that it makes possible an immediate mass market for any product, without which cheap mass-production methods could never be adopted. It is thus both the expression and the initiator of universal wealth. Yet its methods are often questionable—a " long white ash " may identify a cigarette, but does it improve the flavour? Selling seems to have become a matter of putting something into a product or taking something out. Motivation research, subliminal advertising, soft sell and hard sell are household words, but to what extent are their benefits commensurate with the expenditure involved? The hard sell, which resorts to irritation and injunction—" You auto buy now "—has with the advent of the recession taken over from the soft sell, a less demonstrative, gentler, or clowning approach. Motivation research digs deep into the consumer's secret mind to find out why he buys and how best to influence him. Indeed, advertising has played a significant part in the study of communication.

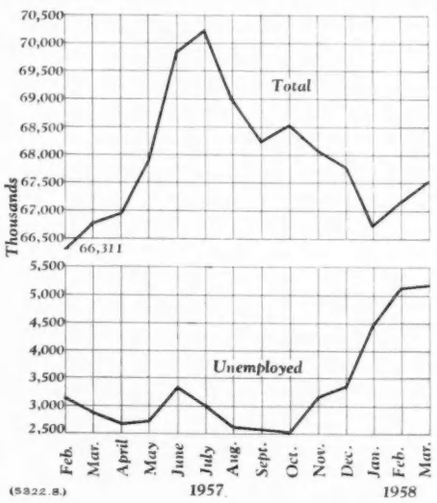
Advertising, with its myriad images beating at the senses, must affect the public in many subtle, incidental ways. Is it a stimulus to the imagination, evoking new impressions with each assault? Does it prompt a critical response, thereby sharpening the edge of scepticism? Or does it, by rendering every issue in terms of simple slogans, so channel thinking as to inhibit it?

More seriously, it may to some extent deter-

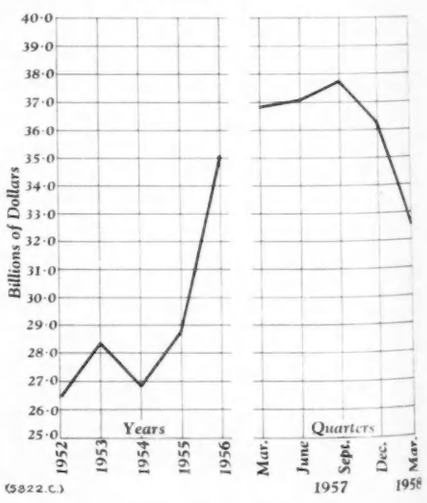
PATH OF THE RECESSION IN TERMS OF GOVERNMENT STATISTICS



Gross national product and income.



Labour force : total and unemployed.



Expenditure on plant and equipment

What They are Thinking and Where it Leads

mine the directions of technical advance, by demanding features that favour sales appeal rather than utility. But though Americans may be influenced by advertising they show few signs of being fooled by it. " Phoney " was after all an American word long before its adoption by the school of English writers that have been gratuitously called " angry young men."

Obviously it has only been possible to give the barest hint of an impression. In any case America is less the things you notice than the ordinary everyday things you take for granted—the matrix in which the exceptional seems to glitter. We read of corruption in the unions and in government because it is exceptional. No doubt the politically successful still dip into the " pork barrel " to pay off their supporters, and certain unions are still in the hands of retired bootleggers, but government and unions are slowly eliminating these abuses. A trade-union official suggested to me that corruption tended to appear more readily where populations were not homogeneous—presumably because of the defensive and aggressive associations that arise. But these aspects of American life are almost unknown to the majority of people.

More apparent is the widespread resistance to government interference; " that government is best which governs least " is an attitude which has survived several centuries, and even the present administration was determined to " get the government out of business "—an aim that seems almost a paradox in terms. It follows that there is a tendency to overlook the interdependence of business and government. Business has long been recognised as the source of American prosperity, and it is not surprising that its rights and privileges are jealously guarded. Government also tends to be an unpredictable authority, and business, so dependent on its capacity to forecast, is bound to view encroachment with suspicion. Self-help and independence continue to be advocated, though the opportunities for their exercise are necessarily more restricted. Nevertheless, unwillingness to be put upon or messed around still serves as a useful safeguard against the approach of 1984.

There is an anxious or systematic questioning of all traditions, including the old faith in the market place and the new faith in measurement. Until recently, measurement using near-scientific methods was ruthlessly applied to all problems, including human ones; at the same time there was a vogue for classifying everything and everybody, and for formulating abstract theories on every subject. Now there is a return to individual case studies and " suck it and see." These and other tendencies will be treated in a later article entitled Trails. But at present in the foreground of American minds is the problem of the recession: are recessions a chronic ailment of the American economy? Will the present one be finished soon? In the following section I endeavour to reproduce authoritative and personal comments I heard, and to draw conclusions.

Economic Climate

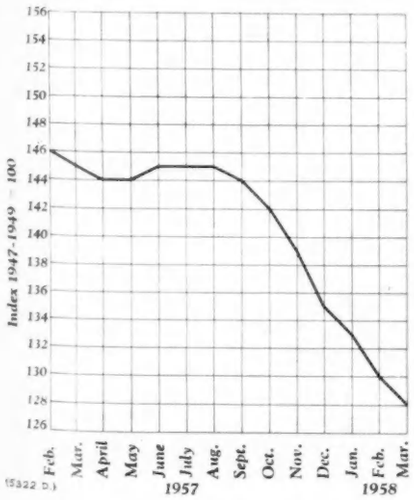
One of the first things I noticed when I reached New York was the curious way in which steam issued from holes in the street. Eventually I discovered that it came from the central-heating apparatus installed beneath the skyscrapers. For buildings of this size, the heating demand must be enormous, and hence the fluctuations in steam requirement will be proportionately great. Steam is presumably released to allow for these variations. Similarly if a country is large and rich the fluctuations in its economy may also be considerable. The business recession in the United States may be regarded as such a fluctuation in which the demand for goods has fallen far below industry's capacity to produce them. It has been called by Mr. Pierre S. du Pont, 3rd, " a problem of abundance."

Now if the boilerman thoroughly acquaints himself with the habits of his tenants and the characteristics of his plant, he will be better able to predict the steam demand and control the supply. Unfortunately a nation is not as simple as a boiler plant; its controls are many times more numerous and in many different hands. However, as economic information becomes more readily available and the mechanism is better understood, it should be possible to introduce compensating devices to damp down unwelcome fluctuations. The advent of automatic data processing has simplified the problem of handling large quantities of information, and comprehensive statistical data are readily available. Indeed, statistical methods thrive on large samples. Why then has the recession not been stopped?

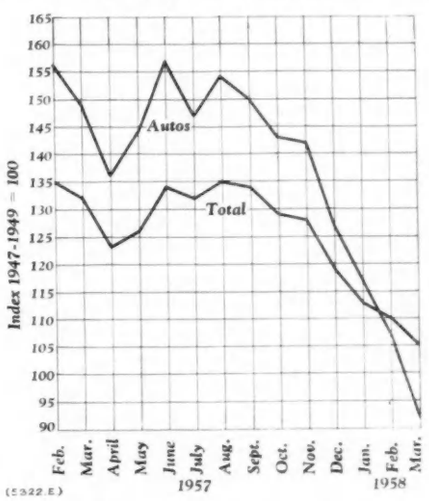
Understanding of the mechanism is necessarily empirical and since recessions are comparatively rare, there is as yet no adequate body of case history. The concept of gross national product (GNP) is a comparatively recent innovation; it is a figure representing the total monetary value of goods produced and services performed during any year. Though figures are available as far back as 1929, the U.S. Department of Commerce only started a detailed analysis in 1932—a procedure that many countries have since imitated. However, even a limited increase in knowledge appears to have restricted the extent of the downturn, and the news that American steel companies are to proceed with a major expansion of their facilities this year suggests that confidence is returning. Nevertheless, with so sensitive a mechanism it is necessary to go carefully.

The material causes of the present recession are fully understood by those whose job it is to understand them; and it is on this increased understanding, and on the comparatively small amplitude of the present downturn, that confidence can be based. Business fluctuations will always be liable to occur, but their magnitude is likely to undergo successive damping as the mechanism and the remedies become better understood. It would be naive to suggest that breakdowns will never recur, but it would be equally naive to accept them as inevitable. Recessions are not a mysterious visitation, and once the present one is ended without reaching unmanageable dimensions the spectre may be laid for years hence.

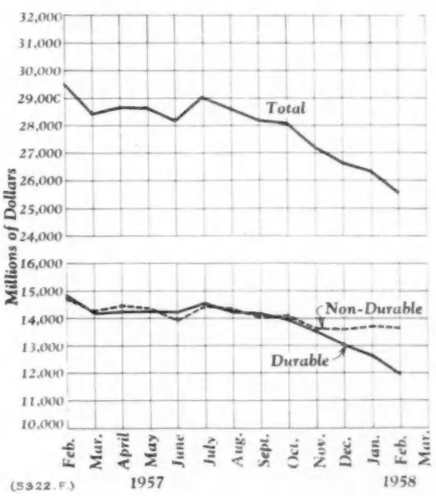
It was pointed out to me that the unemployment figures were misleading, since of the five



Index of industrial production.



Output of consumer durables.



Sales of durable and non-durable goods.

Talking to Americans

million odd now unemployed, not all were breadwinners. Many were young men recently released from the forces; others represented the growth in population; some would be wives and daughters of unemployed men, who in times of stress registered for unemployment; a considerable number would be those recognised as unemployable. Possibly the irreducible figure for the increase in unemployment would be some 1½ million—a relatively small proportion of the total population, which is approaching 168 million. Apart from 1956 and 1957 there were more people gainfully employed now than ever before. But if you were out of a job yourself it would seem a " godawful depression."

When I suggested that things seemed to be getting better to a cab driver in Detroit, he replied despairingly: " Ike says so, but I don't know." The trouble is that everyone knows that Ike's job is to say that things are getting better, so nobody believes him.

RESONANT CIRCUIT

A recession may be regarded as a resonant circuit, in which a fall in confidence is the amplifying factor. The extent of this amplification depends on the way in which individuals interpret the situation. The material economic causes of the downturn will be discussed in detail later, but by the public it is variously attributed to a consumer rebellion, to union demands, to Government policies, and to poor planning in the automobile industry. The effect has been to create caution, thereby encouraging saving and temporarily inhibiting spending. It is said that the level of savings has never been so high. This tendency to save presumably raises investment pressure, and is why stocks have held steady. There has been no panic, only caution: money that may have been set aside for a new car is now placed in the bank, pending a recovery in the situation; this restraint serves further to postpone recovery. " So Dwight Eisenhower says ' Buy,' does he ? " remarks an angry looking man in a *New Yorker* cartoon to his parcel-laden wife. " Well, in the future wait till Sam Winninger says ' Buy '!"

PERSISTENT HIGH PRICES

What is regarded as a curious feature of this recession is the persistence of high prices. Falling demand, it is said, should bring about price reductions. The reasons given by business are the escalator and restrictive clauses in wage agreements negotiated by unions, since if wages remain high so must prices. The unions blame the monopolistic practices of business and freak weather conditions that have kept fruit, vegetable and meat prices high. Because of the price situation many were loth to advocate stimulatory measures, such as tax cuts, in case they led to an inflationary spiral.

The history of the recession as told to me in the Office of Business Management in the U.S. Department of Commerce is outlined below. Subsequently I present supporting or conflicting evidence from other sources and various other comments.

In the United States there has been an average annual increase of 3 per cent in GNP during the first half of the Twentieth Century, and it is considered that an attempt should be made to maintain this figure, though the population bulge may lead to a higher rate.

REMOVAL OF FAVOURABLE STIMULI

In the autumn of 1954 the GNP began to rise at an increased rate, but this upward movement—stemming from a growth in sales, especially of hard goods, and from an expansion in capital investment—was soundly based on increases in population and income, and could therefore not be attributed to overproduction. Nevertheless, the confidence created may have led indirectly to an overexpansion of capital facilities and inventories. Thereafter, what appeared to be a number of favourable developments occurred. These developments were all virtually stimuli to expansion, and it was their removal that caused the downturn. That several effects occurred in combination must be regarded as to some extent fortuitous.

Of these, five will be sufficient to illustrate the trend.

(1) With sales rising, business began to increase its inventories, producing not only for the higher level of demand but in order to accumulate stocks.

(2) In 1955 the automobile industry had a highly successful year, selling 7½ million passenger cars on the domestic market.

(3) Capital investment, which had risen from 26 to 28 billion dol a year in the previous four or five years, increased to a rate above 35 billion dol in 1956-57. (One billion in this context is 10^9.)

(4) United States exports of goods and services rose from 18½ billion dol in 1954 to 23½ billion dol in 1956.

(5) The present administration had inherited a high budget and in their first year undertook to reduce it. Thus Government spending for purchase of goods and services, which had been at a level of 59½ billion dol in 1953, fell by 12 billion dol in succeeding years. However, other factors intervened and by 1957 the figure had again risen to 50 billion dol.

The withdrawal of these stimuli took effect during a comparatively brief period. Thus although the rate of Government spending (5) increased in 1956-57, it subsequently began to decline; certain defence contracts were cancelled, and the aircraft and other industries began to feel the effect. Exports for 1957 (4), though maintaining the high figure of 26 billion dol, reached their peak in the first quarter and then began to fall. The extraordinarily high maximum was the result of various non-sustainable factors: goods and services, including ships, had been required as a result of Suez and the cotton situation, and American exports had been largely financed by draining down gold and dollar reserves.

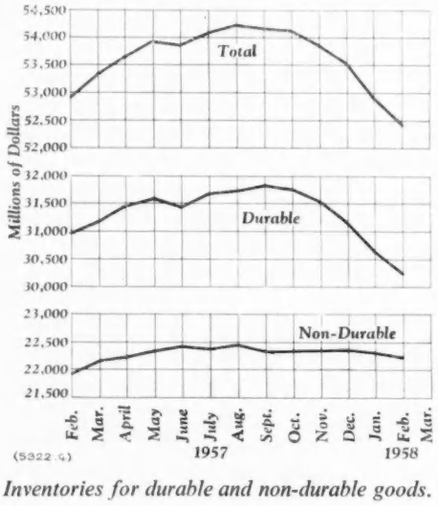
At the same time sales of durable goods began to decline and in the first quarter of 1957 the rate fell from 39·5 billion dol to 35 billion dol, though it was maintained at 35 billion dol until the third quarter. This weakness was readily compounded, and in the automobile industry (2) there was a further disturbing factor in that the 1958 models did not find an easy sale. The changeover occurs in September and October of the preceding year and until that point in 1957, production had been high, since it is necessary to accumulate sufficient numbers of a new model to supply the dealers simultaneously. When sales to consumers turned out to be poor the high rate of production could not be sustained.

INVENTORIES AND INVESTMENT

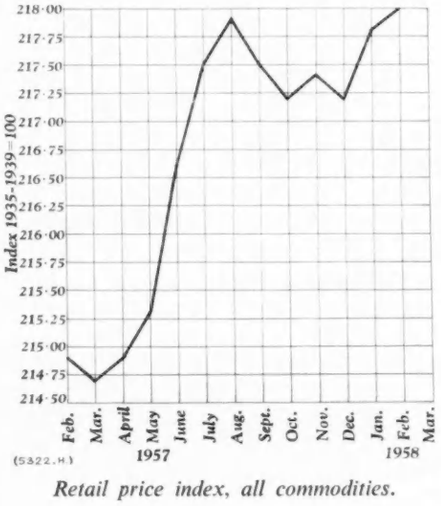
Poor sales tend to have a compound effect in that not only do they reduce production directly but they lead producers and dealers to use up stocks and inventory rather than meet demand from new production (1). In the first quarter of 1957 the growth of inventories had fallen from an annual rate of 5 billion dol (in 1956) to 1½ billion dol, and by the last quarter of 1957 the liquidation of inventories had begun. Inventory liquidation has since reached a rate of 700 million dol a month. However, the level of trading, except in agricultural machinery, has been so high that this rate could be sustained for a considerable period.

Capital expenditure on plant and equipment (3) held steady throughout the first three-quarters of 1957 but declined in the fourth; in the first two quarters of 1958 it was down still further. In 1957 business had spent 37 billion dol on capital equipment and had expected to spend 32 billion dol in 1958.

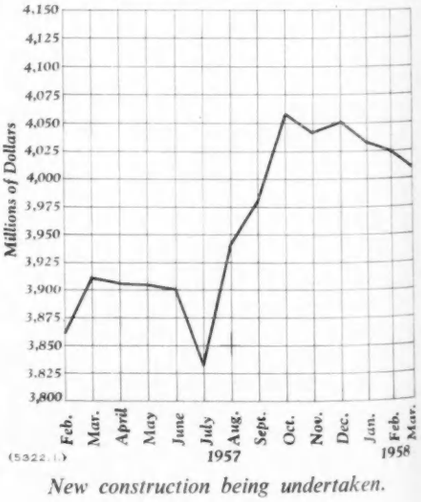
Besides explaining this situation, the deputy director of the Office of Business Economics made the following comments, emphasising that his function was to diagnose rather than prescribe. He told me that steel consumers were in general allowing the producers to carry inventory, so that the situation could not be assessed purely on aggregate figures. Customers had reduced their inventories to such a low level that for rush orders they were highly dependent on the steel producers; if a sufficient number of customers found themselves in this situation simultaneously it would be impossible to meet the demand and it would again be necessary to



Inventories for durable and non-durable goods.



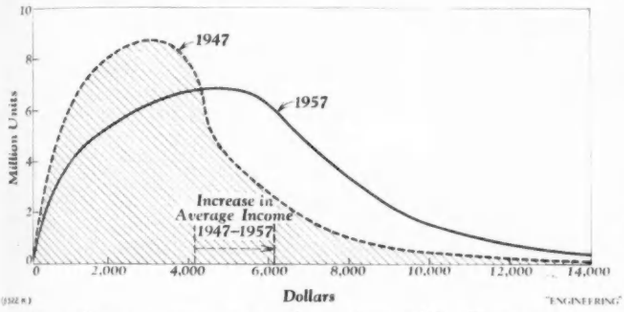
Retail price index, all commodities.



New construction being undertaken.

What They are Thinking and Where it Leads

order ahead so that stocks might once more begin to increase. Recent rises in state and local government expenditure would ease conditions; and the Federal Government has stepped up the rate at which the Defence Department could undertake new commitments—in the third quarter of 1957 the value had been 2·1 billion dol, but in March this year alone it had been 2·4 billion dol. The 1959 model cars would be along in the fall and might prove more popular. I pointed out that the manufacturers were, according to *U.S. News and World Review*, already committed to even larger models; presumably the tooling was already complete before the current outcry against oversize cars had become apparent. In answer, the deputy director observed that in 1958 the largest car with the most chromium adornment had been one of the best sellers.



Spreading out prosperity: the pattern of family incomes.

TRADE UNION VIEW

Fundamentally the views of a spokesman of the American Federation of Labour and Congress of Industrial Organisations research department coincided with the account already given. The basic reason, he said, was a lack of balance between consumption and investment. He emphasised the significance of the 1955 investment boom and observed that it had been partly subsidised and encouraged by the Government. A 1954 change in the tax laws permitted a more favourable system of depreciation, and methods adopted during the Korean War to facilitate plant purchase, whereby a high proportion of the cost could be written off in a few years, were revived in 1956. It was virtually a subsidy for re-equipment.

The precipitatory causes were in his opinion the cut-back in defence and the tight money policy followed by the Federal Reserve Bank. The part played by the automobile industry was not as significant as many thought, and even if automobile sales had been maintained, there would still have been a recession. He believed that the remedies were a cut in taxation, amounting to some 8 or 10 billion dol, with most going to low and middle income families and possibly held for a period to accumulate an encouragingly sizeable sum, and expenditure on public works. Public works is a vexed question; "pork barrel" is, for example, used to describe a 1·7 billion dol rivers and harbours bill in a recent issue of *Time* magazine. The trade unions favoured expenditure on "much needed hospitals and schools." The entire object of such measures would be to increase demand and sales in order to utilise a greater proportion of existing capacity. At present as little as 70 per cent is said to be in use as against 92 per cent in 1955.

A business consultant I met was also in accord with many of the views expressed by the official of the Department of Commerce, remarking that the economy had been on an unnaturally high plateau, but added some other comments of his own. The Government's bad timing in its credit policy had been a contributory factor; tight credit had been relaxed at the wrong moment, when a shock to the system would have been more appropriate. A sudden apprehension at an early stage would have been sufficient to stem the decline.

CONSUMER DISENCHANTMENT

What has been called "consumer disenchantment" has certainly contributed to the downturn. I heard many complaints about the high price of cars and the way auto-manufacturers made the customer pay for chromium he didn't want. Each new car is likely to be larger than the previous model—too long to close the garage door, too wide to get the wife's in by its side. On the other hand, the popularity and durability of the 1955 models seems also to have contributed to the fall in buying—I rode in one that had previously completed 103,000 miles and even its power-operated windows were still in good order. Planned obsolescence is clearly a sales and styling rather than a technical feature of the American car. Poor service and the poor quality of certain goods were other complaints I heard. People have suddenly become determined to get what they want for their money, not what they're told to want. "No-one has given, or seeks to get, value for their money."

Whether or not the car industry was basically to blame, many people including some in Government circles thought it was. Its planning had been incorrect and its measurement of consumer taste misguided—though General Motors has recently announced its plan to build a smaller car and the modest American Motors Rambler has been profiting from the company's "are you plagued by a monster?" advertising campaign. Sales of small European cars had also flourished. In any case, the motor industry is a powerful amplifier and anything that affects it is transmitted to the nation. Not only is it a major customer of the steel industry but any serious reduction in its employee figures has profound repercussions on other local industries, from brewing to postal services.

I was wrong, apparently, to suppose that consumer resistance might arise from people having all they wanted. Many still lived below standard, and you could always discover something new that people were interested in buying.

GOODS OR SERVICES

Employment figures did however suggest that more people were now engaged in services than in directly productive work. Also the cost of services, from greasing a car to a permanent wave, was rising. It appeared to indicate a change in consumer needs and that people had more money left over when they had satisfied their material wants. In addition I was told by a Westinghouse representative that at one time there had been as many as 30 television manufacturers; now with the saturation of the market the number had fallen to less than twelve.

There seems to be a suspicion of market saturation, therefore, at least in certain products. This trend seems likely to be towards flexibility of manufacture and diversification—if the Anti-Trust Laws will allow it. But even services can be mechanised, thereby opening up a new field for manufacture.

Already there are signs of recovery: the machine-tool index is improving, the applications for house mortgages are up, the sale of tinplate is rising, expansion in the steel industry is proceeding, and the rise in unemployment appears to have been broken. It seems fantastic that people should go short because they have made too much, and it may be only a matter of recovering from a temporary economic indigestion. The time has come to get a little slack out of the system. People, though cautious, are

Detroit, storm centre of the recession.

generally confident, and will no doubt work their way back to security. As a business man remarked, the recession has had a salutary effect. "Trees don't grow up into the sky," and the economy had reached artificially inflated levels.

To summarise in the words of the same man: "Inventory was high, capacity was high, and prices were high, when someone jerked the carpet." The structure was shaken but is still standing and for the moment everyone is sitting tight.

Price List

In understanding the American economic situation a list of current prices may provide a useful guide.

Exchange rate: £1—2·8 dol, 5s.—70 cents, 2s. 6d.—35 cents, 9d.—10 cents, 6d.—7 cents. A dime is 10 cents and a nickel 5 cents.

Newspapers: 5 cents, home city, 10 cents elsewhere.

Fares: subway, New York, 15 cents any distance, streetcar, Washington 20 cents, taxi, Washington, 50 cents between zones, New York, 25 cents first ⅛ mile, 5 cents each further ⅛ mile, aircraft, Washington to Boston (400 miles), first class 30·36 dol, tourist, 23·43 dol.

Hotel: one night, without meal, 8 to 10 dol.

Rent: 80 dol plus per month for average apartment.

House purchase: 8,000 dol.

Meal: 2 dol drugstore, 5 dol Super Chief, 95 cents Harvard Business School canteen.

Automobile: 2,400 to 3,000 dol with accessories, including paint. List price, less accessories, as low as 1,600 dol or nothing down and 70 to 80 dol per month (at present).

Gasoline: 3 U.S. gal for 1 dol (best) or 27 to 30 cents per U.S. gal. 34 cents for Imp. gal.

Post: airmail abroad, 15 cents (card 10 cents), airmail, internal 6 cents (surface 3 cents).

Haircut: 1·25 to 1·75 dol.

Dentist: filling 6 dol, extraction 10 dol; two out, six filled, one straightened, 141 dol.

L.P. Record: 4 to 6 dol (12 in 33 r.p.m.) but specials at 1·98 dol.

Paperback Book: *Three's a Shroud*, 25 cents
Poems of Robert Frost, 35 cents.
The Brothers Karamazov, 50 cents.
The Organisation Man, 1·45 dol.

Nylon stockings: 1 to 2 dol.

Tips: 10 to 20 per cent, minimum 10 cents.

Tea: 75 cents per ½ lb.

Coffee: 89 cents per lb or 4½ dol for 5 lb.

Meat: 1·65 dol a lb (sirloin retail price).

Butter: 72 cents a lb.

Oranges: 17 to 19 cents a lb.

Milk: 22 cents per U.S. quart.

Sugar: 82 cents for 5 lb.

Coca-Cola: 5 cents or 10 cents, depending on the State.

Wages: Lathe operator, 75 to 100 dol a week.
Average income, 6,000 dol a year.
Lowest income, 2 000 dol a year.
Chairman of corporation, 600,000 dol a year.

Taxes: Federal, 92 per cent max. (progressive).
State (Delaware), 1 per cent on first 1,000 dol, 2 per cent on second up to 8 per cent.
County or Township, based on valuation, also excise tax, entertainments tax, sales tax, property tax.

Atomic Review

Notes and News

In contrast to previous weeks, no one theme predominates in this section to-day. Notes on a variety of topics are included.

Irradiation Service

Metropolitan-Vickers Electrical Company Limited have opened a new irradiation laboratory at their Barton Works, Trafford Park, Manchester. A 4 MeV linear accelerator is used and equipment has been put in to handle a range of different products. Among the applications in which irradiation may have advantages are the curing of rubbers (particularly the silicon variety), the processing of plastics, the disinfestation of grain, and the preservation of foodstuffs. For these, and for other applications that may arise, the company say that "the laboratory service will provide for specific investigations without involving the interested parties in the purchase of equipment and the maintenance of trained personnel." Some contract work will also be done.

The waveguide system of the accelerator is tuned to 2,998 Mc/s and an automatic tuning circuit is used to pull the magnetron to this frequency. A bridge circuit linking the magnetron to the waveguide builds up the peak power input to 4 MW. However, the mean input remains at about 2 kW, the pulse duration being reduced.

Output powers up to 1 kW can be produced with the present machine. When the electron beam leaves the accelerator, however, it is of small cross section and low divergence. To enable maximum use to be made of this concentrated beam, scanning techniques are employed. The beam passes through a coil that carries a rectangular current waveform with a maximum frequency of 10 c/s. The scanner assembly, Fig. 2, has an output window of aluminium foil, to maintain the vacuum within the waveguide, and an area of 12 in by 0·75 in is scanned by the emergent beam. As the lowest pulse repetition frequency of the bunches of electrons in the beam is 50 c/s, there will be at least five beam pulse for each traverse.

A conveyor passes in front of the scanner at a speed that can be varied from 6 to 48 in per min. Also a motorised work-holding table is installed. This provides vertical lift, traverse, and rotation in the vertical and horizontal planes. The table can be controlled from outside the treatment cell; it can also be adjusted inside the cell for setting up purposes. Being constructed of slotted angle, the table has a large number of fixing points to secure the small jigs and fixtures that are required for some classes of work.

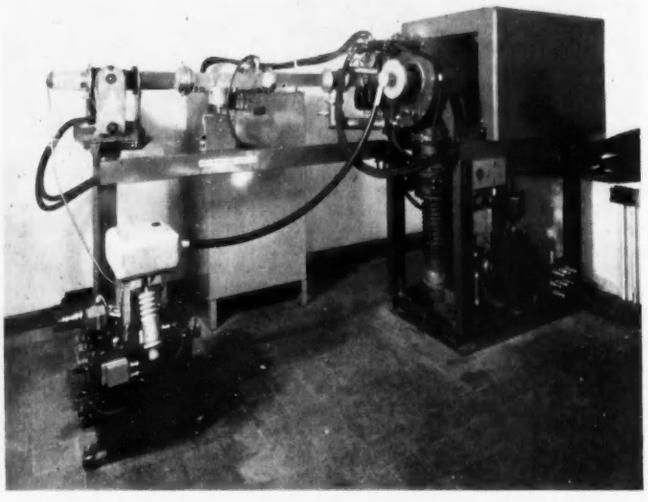


Fig. 1 The 4 MeV linear accelerator used for irradiating materials with electrons is basically similar to clinical machines which have been used for X-ray work.

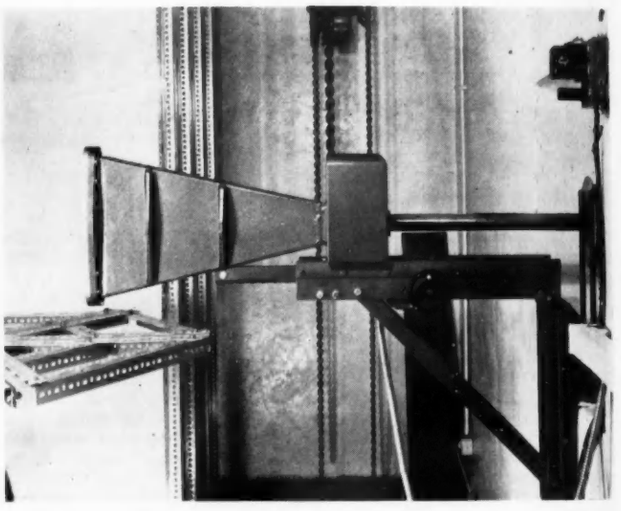


Fig. 2 For irradiation work it is necessary to dispense with the normal target used to produce X-rays and to fit a scanning mechanism that sweeps the narrow pencil of electrons over a wide area.

Irradiation is frequently carried out by electrons or X-rays, which may be from particle accelerators, atomic piles, or waste fission products. Broadly speaking the effects are similar. Irradiation by high energy electrons provides an efficient process because the electron beam has a fairly sharply defined depth of penetration: the dosage can be concentrated within the product being treated. X-rays, on the other hand, have a much greater range of penetration; and unless a large bulk of material is to be treated, very little energy is absorbed. Also the low conversion factor in the production of X-rays by target bombardment gives low overall efficiency.

In the linear accelerator at Metropolitan-Vickers, Fig. 1, the electrons are accelerated along an iris-loaded waveguide by radio frequency power. A 50 kV electron gun produces bunches of electrons widely spaced in phase and the initial section of the waveguide concentrates the bunches of electrons. The final section accelerates them to energies of about 4 MeV. Radio-frequency power is provided in 2 microsecond pulses by a magnetron operating in the S-band (3,000 Mc/s); its output is 2 MW peak. The pulse repetition frequency can be varied from 50 to 500 c/s and mean powers of about 2 kW are achieved.

Atomic Energy Appointments

The United Kingdom Atomic Energy Authority announce the following new appointments in the Industrial Group: Mr. P. T. Fletcher, formerly director of engineering, becomes a deputy managing director; Mr. H. V. Disney, formerly deputy director defence plants, supplies and services, becomes director of engineering; Mr. R. V. Moore, formerly deputy director, civil reactors, becomes director of reactor design.

Nuclear Ships must be Economic

In a letter to Mr. G. R. Chetwynd, Labour member for Stockton-on-Tees, the Prime Minister has emphasised that national prestige would be served best by launching a ship which would be economic to run, or well on the road to being so. Mr. Macmillan stated in his letter that the United Kingdom Atomic Energy Authority were working on the design of a land-based advanced gas-cooled reactor and that construction would start later this year. This plant, he wrote, was designed with a view to flexibility of performance and operation and would provide good experimental facilities particularly for the development of fuel elements to withstand long burn-up at high temperatures. Although not primarily a prototype for a marine propulsion unit, such an application might stem from it if development work made good progress.

The Prime Minister added that the UKAEA had agreed with the Admiralty to associate, at Risley, with representatives of the shipbuilding industry and of the Yarrow Admiralty Research Department. Arrangements had also been made for regular technical conferences between the Authority and the shipping and marine industries, on the application of the technology of the advanced gas-cooled reactor to ship propulsion. Surveys of other possible reactor systems for marine propulsion would continue and it was hoped that evaluations would be completed by next April, so that a reactor could be chosen. He added that technical development was at too early a stage to be firm about the date when the first nuclear propelled ship would be ready for sea trials, but if all went well it should be 1964.

Dounreay Reactor "Critical"

In the early hours of Saturday morning, 24 May, the Dounreay Materials Testing Reactor went into operation. Dr. Robert Hurst, director of the United Kingdom Atomic Energy Authority Dounreay Research Establishment at Caithness, Scotland, guided into position the rod containing enriched uranium fuel which made the reactor go critical. This is the first of the three reactors for the Dounreay site. The other two are the fast-breeder reactor housed in the giant sphere which now dominates the local coastline, and the Admiralty's land-based submarine prototype.

ETR At Full Power

The United States largest and most advanced nuclear test facility, the Engineering Test Reactor (ETR) at the AEC's National Reactor Testing Station, Idaho Falls, is now operating at its full design power level of 175 MW (thermal). This reactor became critical initially in September, 1957, but pending modifications to the fuel

elements and primary coolant pumps, the power output had been limited to 9 MW. It will be used to test the effect of exposure to high-flux radiation on components of reactors being designed.

Mishap at Chalk River

A uranium fuel rod which caught fire in the Chalk River reactor building after it had been removed from the reactor has made it necessary to shut down Canada's 57 million dol. plant. The incident was announced by the Atomic Energy of Canada Limited as having occurred during Whitsun weekend. Although the fire was quickly extinguished, radioactive dust spread throughout the interior of the building, and a nearby road was also affected. No one was injured and it is expected that it will be possible to start up the reactor again in three or four weeks when the affected areas have been decontaminated.

DCL and Chapel Cross

The chemical division of the Distillers Company Limited, which provided liquid carbon dioxide bulk storage and evaporation equipment for Calder Hall, has been responsible for a similar installation in the new station for the UKAEA at Chapel Cross.

The complete installation designed by the Distillers Company includes five thermally insulated bulk storage tanks, each with a capacity of 20 tons of liquid carbon dioxide and with a pressure-operated refrigerator and safety valves, together with six evaporators, each capable of vaporising 3 tons of liquid carbon dioxide per hour.

The storage tanks were fabricated by John Thompson Limited, of Wolverhampton; insulation was carried out by Dick's Asbestos and Insulating Company Limited, of Silvertown; the stop valves were supplied by Newman Hender Limited, of Woodchester, near Stroud, Gloucestershire; and the safety valves and evaporators were designed and made by the DCL engineering development section at Epsom.

OEEC Training Course on Nuclear Energy

Two international training courses are being organised by the European Nuclear Energy Agency to enable senior technical executives to increase their knowledge of the technical, economic and industrial aspects of nuclear energy.

Each of these courses will have facilities for some 30 participants from OEEC countries and will consist of lectures on problems in physics, chemistry, electronics, metallurgy and mechanics related to the construction and operation of reactors, as well as on preparation and chemical processing of fuels. The programme is designed to allow time for discussion, and will comprise numerous experiments and visits to installations.

A first course in French will be held with the help of the French Atomic Energy Commissariat from 15 to 25 July at the Nuclear Research Centre of Saclay (France). A second course in English will take place from 18 to 29 August at the recently opened Netherlands-Norwegian Reactor School, attached to the Joint Establishment for Nuclear Energy Research (JENER) at Kjeller (Norway).

Inquiries for information should be sent to appropriate national bodies, or to the European Nuclear Energy Agency, OEEC, 2 rue André Pascal, Paris, 16e.

United States Offer Enriched Fuel

The U.S. Atomic Energy Commission have announced a new policy regarding the supply of uranium reactor fuel enriched to more than 20 per cent in the uranium 235, which has been available to friendly nations under the Atoms-for-Peace programme. Up to the present, the supply of this fuel has formed part of a comprehensive agreement for co-operation that also provided for assistance in the construction and operation of a materials-testing reactor. There are nine such agreements and in each case the arrangement has been for the supply of fuel enriched up to 90 per cent uranium 235 in limited amounts of 6 kg for a reactor.

Under the new policy, the Commission is prepared to consider requests for highly enriched fuel for both research and materials test reactors when such fuel is economically and technically advantageous as compared with fuel of up to 20 per cent enrichment. The amount which may be made available will be increased up to 8 kg per core loading, and co-operating nations may request enriched fuel for more than one materials reactor. An agreement for co-operation with the United States containing comprehensive safeguards and controls against the diversion of nuclear material to military use, would be required. Also, nations considering making requests for this enriched fuel should have definite plans for reactors requiring this type of fuel.

U.S. Observation Programme for Nuclear Weapon Tests

The U.S. Atomic Energy Commission has outlined the general arrangements under which scientists from 14 nations, to be invited through the United Nations, may witness the detonation of a large nuclear weapon and the analysis of the resulting radioactive debris.

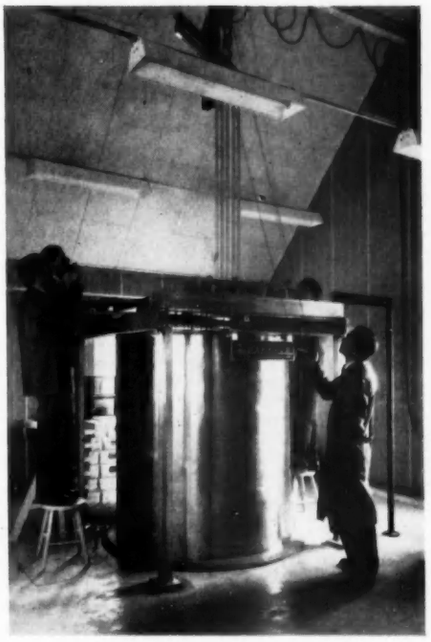


Fig. 3 The uranium rods and upper aluminium unit for Finland's new exponential pile were supplied by the United Kingdom.

This programme, scheduled for July or early August, is designed to give the scientific observers information and data demonstrating the progress which American scientists have made in reducing radioactive fallout from nuclear explosions without revealing important information concerning weapon design.

The scientific observers will be assembled at the University of California Radiation Laboratory at Berkeley, California, about one week prior to their departure for the forward area. At Berkeley they will be briefed on the technical and scientific aspects of the programme. The observers will then proceed to Honolulu and from there will be flown to the Eniwetok Proving Ground. They will be in the proving ground about one week prior to the scheduled date of the detonation. This period will be used to familiarise them further with the programme and they will be able to inspect and discuss the instrumentation provided by the test organisation for determining the fission and total yield of the test device.

After the detonation, the scientific observers will return to the University of California Radiation Laboratory at Berkeley for a period of about one week.

Dr. E. O. Lawrence, UCRL, Berkeley, is the United States representative in dealing with these arrangements and Dr. Gerald W. Johnson, UCRL, Livermore, will be the technical director for the project. United States and foreign news representatives will be invited to attend the observation along with the U.N. scientific group and to accompany the scientific observers to the extent practicable.

American Research Reactor for Sweden

The U.S. Atomic Energy Commission has given notice that it proposes to issue a licence to ACF Industries, Inc., New York, for the export of a testing and research reactor to Sweden's new atomic research station at Studsvik. Progress at this research station was described in ENGINEERING, 9 May, 1958, p. 589. The value of the proposed shipment is stated to be 1,850,000 dol.

Mr. Lewis L. Strauss, chairman of the Commission, has also announced that the United States Government will contribute 350,000 dol towards the Studsvik atomic research station and will make the necessary fuel required for the research reactor available under the terms of the agreement for co-operation in effect with Sweden.

The Swedish Government has estimated that the cost of this research reactor (R-2), reactor buildings and auxiliary facilities, will be around 4,295,000 dol. About half of this amount will be for the manufacture and installation of the reactor. Swedish firms will construct the building and associated facilities. This reactor is part of Sweden's programme to develop power reactors for district heating and power purposes.

Finland's Exponential Pile

A new exponential pile has been built by Ydin, the Finnish Consortium. The uranium rods and upper aluminium unit were provided by the United Kingdom, while the graphite reflector was produced by the Union Carbide Corporation of the United States. The neutron source is Russian, has a 10 curie strength, and is of the polonium-beryllium type. (Fig. 3.)

U.S. Contribution to Geneva Conference

The chairman of the United States Atomic Energy Commission has announced that approximately 900 abstracts of scientific and technical papers have been forwarded to the United Nations and proposed for presentation by the United States at the United Nations Second International Conference on the Peaceful Uses of Atomic Energy to be held in Geneva, Switzerland, from 1 to 13 September 1958.

The President of the 1958 Conference will be Professor W. Perrin of the Commissariat à l'Energie Atomique de France, and the Secretary-General will be Dr. S. Eklund of Sweden. Edward S. Gardner is executive director of the USAEC Office for International Conference, which was established to carry out plans for United States participation. Dr. L. D. Percival King of the Los Alamos, New Mexico, Scientific Laboratory, is technical director.

Following the 1955 pattern, there also will be a commercial atomic energy exhibit in Geneva. This showing, called the International Exhibition on the Peaceful Uses of Atomic Energy, will be held at the Palais des Expositions. The United States part of the presentation, co-ordinated by the Atomic Industrial Forum, will feature industry and Government displays.

Course on Control and Instrumentation of Reactors

A course on the control and instrumentation of reactors is to be held at the Harwell Reactor School from 6 to 11 October 1958, inclusive. The fee for the course will be 25 guineas, exclusive of accommodation. Application forms and further details can be had from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire.

Special Article

THE ADVANCING ROTODYNE

The capabilities of Britain's prototype vertical take-off and landing airliner, the Rotodyne—claimed to be the world's first commercial V.T.O.L. aircraft—have now been publicly demonstrated by the makers, the Fairey Aviation Company Limited, Hayes, Middlesex, at their White Waltham airfield.

The Rotodyne, shown in Fig. 1, takes off, lands, and hovers as a helicopter—and, in this condition, has all the helicopter's manoeuvrability. In cruising flight it behaves, in effect, like a conventional aeroplane, free from the very low speed limitations of the helicopter; in this state, the rotor " free-wheels " in autorotation, and shares with the small fixed wing the lifting of the aircraft, which is propelled forward by two conventional tractor propellers mounted on the wing. Transition from the helicopter to the cruising regime is a gradual process, carried out at about 1,000 ft altitude, and is said to be undetectable by the passengers—and a simple operation for the pilot. On the ground, transition can be detected only audibly, as the Fairey pressure jets at the rotor-blade tips go out of action.

The prototype Rotodyne is unsilenced—but the Fairey company are very conscious of the need to provide an acceptable noise level for an aircraft that is intended to operate right from the centre of the city, and they have in an advanced state of development a silencer which they expect to be fully effective (Fig. 2). To one casual observer of an isolated flight or two, the noise made by the prototype Rotodyne when the pressure jets were in operation appeared rather pleasing, like a gigantic steam locomotive—but, nevertheless, one would not choose to live beside it. In cruising flight, the character of the noise is completely altered—the unloaded rotor blades contribute very little and the predominant noise is the quiet hum of the Napier Eland propeller turbines.

To venture on the construction of a 48-seat passenger machine embodying new propulsion units and an aerodynamic concept that has not previously been tried in practice is a bold step—but the smoothness with which the initial flight trials have proceeded since the first flight on 6 November last year confirm the soundness of the basic ideas, and of their engineering execution. Preliminary performance measurements, we are told, suggest that the machine may well surpass the designers' predictions (Table I). It is Fairey's conviction that they have given birth to an aircraft that, for the first time, makes city-centre to city-centre aerial transport a really economic and commercially attractive proposition. Their faith in the project is demonstrated by the fact that they intend to press on with the development to certification standard—the cost of which is estimated at some £8 million to £10 million—whether or not they get the full government support that they feel the Rotodyne merits.

Fig. 1 The Rotodyne in flight.

The claim to economic superiority of the Rotodyne over conventional helicopters is based, primarily, on its much higher cruising speed—which, for the production version, is estimated at 185 m.p.h. Another factor is that it can carry a higher proportion of disposable load to all-up weight than has previously been customary—due to the elimination of heavy transmission shafts and gearing made possible by the adoption of tip-jet reaction drive. The use of pressure jets at the rotor-blade tips does, it is true, introduce certain problems that the shaft-driven rotor escapes—such as the design of effective combustion chambers, and the necessity for conveying fuel, air and ignition leads through rotor head and blades. These problems, however, have already been overcome by intensive rig development and, in the large helicopter, the weight saving of the reaction drive really " pays off."

The Rotodyne is still at the threshold of its career, and before it can acquire a certificate of airworthiness it must build up thousands of flying hours to prove its strength and reliability. Thus, it is not expected to be certified until 1961. To date, the Rotodyne has accumulated some 80 flying hours—mainly in the helicopter state: transition to the cruise condition was first carried out on 10 April. Tests so far have been concerned with structure integrity and flight handling. The loading on the rotor blades is naturally more severe when the tip-jets are in action; and, because the vibration modes and stress distribution in a rotor blade under dynamic loading are extremely complex, detailed strain gauging records are imperative for every phase of flight to ensure that no unsuspected peak stresses are encountered.

The instrumentation installed in the prototype is, in fact, extremely comprehensive (Fig. 3) Three auto-observer panels are fitted, the essential instruments being monitored by human observers. In addition several hundred strain gauges are fitted, both to the rotor and to the airframe, rotor gauge indications being transferred to the fuselage recorders via slip rings.

Following the initial flights at low speed, the cruising speed was increased step by step to the present value of 155 m.p.h. At each stage comprehensive strain gauge measurements were made to assess the magnitude of fluctuating stresses, blade flapping angles, clearance from droop stops, airframe vibration levels and so on. The measured fluctuating stresses are compared with the results achieved in the laboratory fatigue tests, to ensure that adequate safety standards are maintained.

Fairey report that, from the outset, the cyclic and collective pitch controls were found to be crisp and precise (Fairey hydraulic booster controls are used, with duplicate sources of hydraulic power). The behaviour of the rudders and elevators at forward speed has been satisfactory, the elevators in particular giving a powerful control of fuselage attitude. Wind

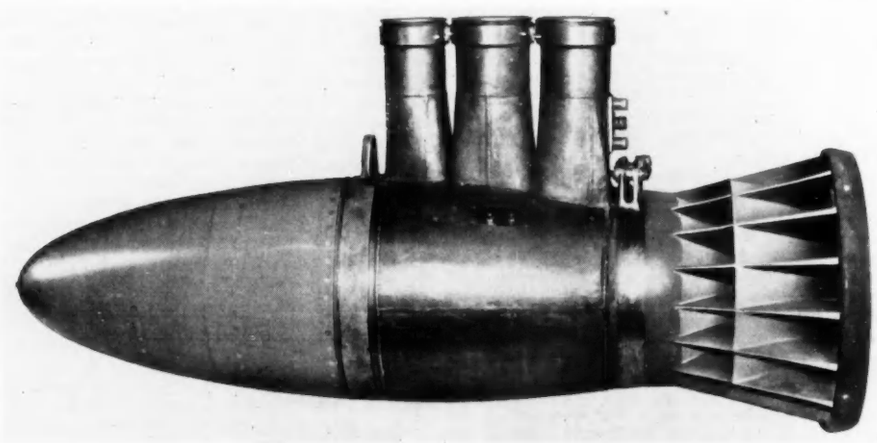
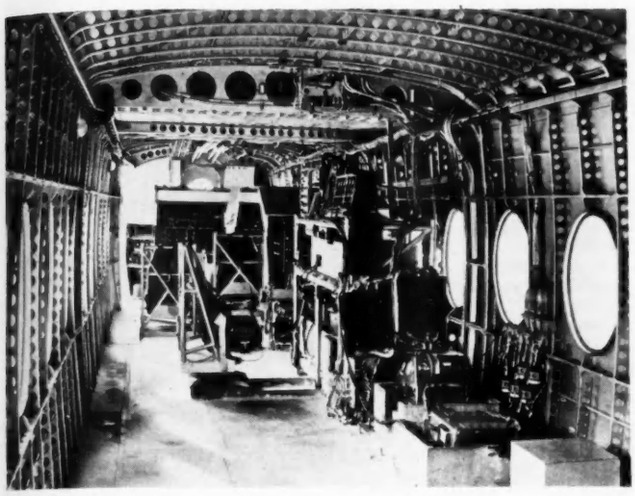


Fig. 2 Tip jet propulsion unit with experimental silencer.

Fig. 3 Flight instrumentation installed in the prototype Rotodyne.



tunnel tests had indicated that only small longitudinal trim changes should occur as the aircraft gains forward speed from the hover or moves out of the ground cushion. Flight experience has proved this to be true.

As already indicated, comprehensive performance tests have not yet been carried out, but present indications are that hovering performance and vertical climb are considerably better than had been predicted. The following figures represent the figures so far reached with the present prototype at 33,500 lb: vertical rate of climb, 1,300 ft per min at partial power; level speed, 155 m.p.h. at partial power; forward climb, 2,400 ft per min at partial power; maximum altitude, 7,000 ft.

TABLE I.—*Dimensions and Estimated Performance of Production Rotodyne*

All-up weight	39,000 lb
Fuselage—external length	58 ft 8 in
internal cabin length	46 ft
internal cabin height	6 ft
internal cabin width	8 ft
Wing span	46 ft 6 in
Rotor diameter	90 ft
Height, overall	22 ft 2 in
Main power units	Two 3,500 e.h.p. Eland propeller turbines
Rotor power units	Four 1,000 lb thrust Fairey pressure jets
Propellers	13 ft diameter, Rotol
Cruising speed	185 m.p.h.
Maximum range	450 statute miles
Maximum payload	48 passengers, or 12,000 lb of freight or mixed loads
Specimen operations	48 passengers (9,000 lb) over 200 miles
	34 passengers (7,000 lb) over 400 miles
Operating cost	Approx. 4*d.* per passenger mile

One bugbear that has grounded many types of helicopters is the ground resonance problem—the interaction of fluctuating loads on undercarriage and rotor which may give rise to destructive vibration. Before the Rotodyne commenced flight trials, this problem was tackled by theoretical analyses backed up by tests. A 1/15 scale dynamic model reproduced the stiffnesses and inertias of the blades, airframe and undercarriage—though not, of course, the aerodynamic characteristics of the blades. Extensive tests were made to check the behaviour of the model and also to correlate theory with experimental results. At a later stage the actual prototype was subjected to tests designed to measure the distribution of stiffness and damping available.

To carry out these full-scale tests, the rotor head and blades were removed and replaced by an equivalent mass. A rotating out-of-balance force was then fed in at the head, and airframe response at all critical points measured over a range of frequencies from 0·5 to 3 cycles per sec. In order to simulate the effect of lift, the complete airframe was slung to a jib and varying lift forces up to the aircraft maximum weight were applied while the tests were in progress. The very low frequencies involved made it necessary to apply the lift force through air jacks to give a soft suspension. The test information was fed back into the model tests, and a complete ground resonance picture obtained. It became evident that among the various modes of vibration, a rather unusual combination of circumstances existed in which the aircraft might encounter ground resonance. While a new retractable undercarriage was being designed to avoid this trouble, the original design was fixed temporarily in the down position, using rigid bracing struts so as not to delay initial flight testing. The final full-scale ground resonance and power-plant clearance tests were accomplished in five days.

Fig. 4 The wide cargo doors give entry to an unobstructed fuselage.

A full-scale rig built at the Aircraft and Armament Experimental Establishment at Boscombe Down, where the jet units could be run continuously without offending the public, has been found to be invaluable; the tip jets took their final approval test on it together with the rotating seals at the head. The mechanical reliability of the head itself, including bearings, hinges, control, etc., was established for an initial safe life; engines and propellers, together with their controls, were subjected to careful functioning tests; and the control cabin was laid out so that the pilot became thoroughly familiar with the control positions.

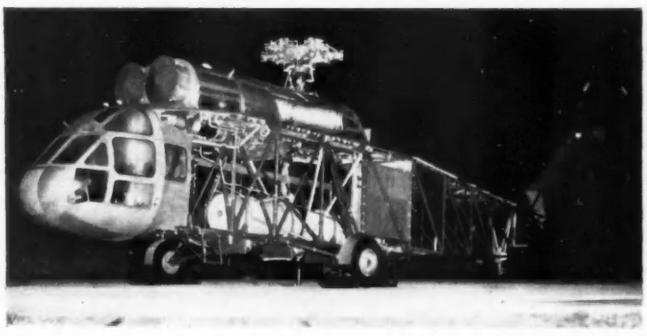
There have as yet been no firm orders for the Rotodyne, which has until the last few weeks been an unknown quantity. Now, however, the makers look forward to the near future when they will be able to offer firm, proved performance figures to the many operators who are interested in the Rotodyne—among them British European Airways, Air France, Sabena, New York Airways, Chicago Airlines, Silver City Airways, and Japan Airlines.

Earlier articles in ENGINEERING on the Rotodyne and its propulsion system appeared in the 14 Sept. '56 issue (Progress with the Rotodyne, p. 344), and in the 10 May '57 issue (Pressure Jets for Helicopters).

WESTMINSTER HELICOPTER COMPLETED

Construction of the prototype Westminster helicopter has now been completed by Westland Aircraft Limited, Yeovil, Somerset, and ground tests will shortly commence. The Westminster, which is capable of lifting a load of six tons or more, has a shaft-driven five-bladed rotor, 72 ft diameter. The drive is by two 2,800 h.p. Napier Eland gas turbines, mounted side by side.

The prototype Westminster, of welded-tube construction, is a "utility" version for use as an aerial crane, embodying a strong load point in the structure. As a military machine it is expected to have many uses—either for long-range duties such as anti-submarine operations, for the lifting of heavy weapons, or for the carriage of troops or freight. An airliner type of cabin has also been designed for the Westminster, with 42 seats.



The Human Element

Transferable Security

The Engineers' Guild has of recent weeks come out strongly in favour of the transferability of pensions in professional work. The case has been argued in terms of the engineer, but of course it applies equally to other kinds of professional work. It is said, and the argument is just as valid for all kinds of work, that non-transferable pensions make it difficult for good men to get experience.

The case is particularly apposite for some sections of the engineering profession since some engineers move from one large contract to another and, in the process, from one employer to another. The case is better argued, however, with respect to the profession in general. If a man has to change his job the case for giving him a transferable pension has little to do with enterprise. The argument is in such a case for giving a man some security against the hazard of his occupation.

Transferability of pensions is best argued as an antidote to a pre-occupation with security. The engineering profession will suffer if good men do not get to the top but become bogged down as specialists. In these days it may be too hard a doctrine to say that men should not put security first when young. This assumes that men have the chance to save substantial sums when they get older and not many can do this at to-day's rates of taxation. If less stern ideas must be accepted, increased mobility of pensions as well as men is a good compromise. There is, however, an alternative approach: that on changing his job the man should leave his paid-up pension rights in "cold-storage" with his former employer until he reaches retiring age when he will draw only a proportion of the full benefit. This approach also has its attractions.

Mothers at Work

In a period of rising unemployment, the problems of married women wanting to work are unlikely to provide a very popular topic of conversation except among themselves. In certain parts of the country—South Wales, for example—the jobs of women, jobs for which they are particularly suited, are being threatened because one in ten of the men are out of work. This in no way deterred the National Council of Women of Great Britain from discussing the problems of women at work at a conference held in London last week. The council's president, Lady Reading, made it clear that the conference were not concerned with the ethical aspects of whether mothers should or should not take paid employment, but with "the fact that a large and ever-increasing number are doing so."

The delegates were unable to agree on the effect of the mother's absence on the children, but many expressed concern with a speaker's warning that "when Mum went to work, the emotional climate at home changed for the worse." It was recognised that the wish to work was born out of a desire for outside interests rather than out of financial need. The fact that one-third of the country's labour force—8 million—is at present female, and half of it married, makes the problem a sizeable one.

10 to 1 on

Mr. Sandys, Minister of Defence, is prepared to offer 10 to 1 that the Forces will get their target of 375,000 regulars by 1962. The reason for the increase in confidence is the much improved recruitment figures recorded in April, and figures which are expected to have been equally good for May.

It was in April that the new code for pay and allowances came into operation and there was an encouraging response. This was especially so for the Army. Taking all the Services together there were 31,300 man-years recruited in April this year compared with 17,200 for the same month of 1957. The Services aim to recruit 388,000 men to give an allowance for wastage above the official target of 375,000 net.

It is the old and simple story that you can get what you want if you are prepared to pay for it. It has taken the Forces a long time to break away from the tradition that the pay of the other ranks (slightly different factors operate for commissioned ranks) is a cross between a feudal token payment and a poor market rate for unskilled labour. Making war to-day is a technical business and needs skilled men, who command a good wage, to do it.

Realism in Wage Demands

A new approach to wage claims and policies was urged by Mr. J. Cooper in his chairman's address to the annual congress of the National Union of General and Municipal Workers last week. This is the first time a senior trade union leader has gone so far in linking wage claims with rising costs. "Have we as a movement," he asked, "gone far enough in playing our part towards solving the problem of inflation?" and went on to point out that most of the wage rises obtained by trade unions over the past few years have been "swallowed up" leaving the workers no better off. His advice to the trade union movement was to be "willing to look for modest, real wage increases instead of demanding substantial concessions which, if realised, can only aggravate our economic difficulties."

This speech must have sounded almost too good to be true to the ears of the Prime Minister. It is precisely the attitude he has personally attempted to foster among trade union leaders and in industry generally. Whether we as a country ride on the crest of a wave, as in the past twelve years, or fight for survival in a depressed world economy, the need to control our price levels remains the same. All concerned in the industrial process have a clear interest in maintaining the purchasing power of the wages, salaries or profits they earn. The idea relating the level of wages in particular industries to productivity has never been very convincing, since all industries have not the same potential for increasing productivity and since within industries important differences exist between individual firms. Mr. Cooper's plea for a centralised approach, as through the general council of the TUC to the Government, is altogether more sensible and realistic.

A Union on Expansion

An immediate relaxation of the Government's restrictive policies was called for at the annual congress of the National Union of General and Municipal Workers by Sir Thomas Williamson, their general secretary. His speech expressed very well the current union thinking on the economic situation and their very real fears that the Government's policy is not improving matters. "I believe," he said, "that we have now reached a turning point in economic policy. The Government should and can relax some of their restrictive policies and take action to restore the growth of an economy making use of the considerable productive capacity we still have at our disposal."

This criticism of the Government's approach to economic problems has been made by many outside the trade union movement. But Sir Thomas, along with Mr. Cousins and most other leaders, see in it a threat to the standard of living and an abandonment of full employment as a first objective. They fear the return of poverty and large-scale unemployment. Sir Thomas Williamson's main supporting statistics were 500,000 unemployed and percentages of 8 to 9 per cent in some areas. But why should we be losing ground in export markets, he asked—"is it because of price, or quality, or delay in delivery?" He could have added "or because we are not making the right products." To provide an answer to this question is, as he said, the Government's urgent responsibility.

A Better Start

As from the autumn, the parents of state scholars and students at teacher training colleges will receive more help in the way of larger grants. There is a limit to the power of the Minister of Education in reducing the burden, but he is taking the full discretion which is left to him under the Education Act, 1944. The two main changes are the provision of equal steps in the increase of parents' contributions (compared with rising ones at present as income rises) and an increase in the maintenance payments to students.

Parents' incomes are assessed for contribution on what is called a "scale income." Fairly substantial allowances are made in arriving at scale income from gross income. Thus insurance premiums, mortgages interest and special educational allowances are deducted. These can in total be substantial. The new contribution scale after the income level has been calculated is more generous than before and, as stated, the steps are equal.

The rise in maintenance allowances is considerable. For Oxford or Cambridge, hall or lodging allowance goes up from £283 to £325. At London, college allowance goes from £252 to £280 with other types of allowance going up accordingly; at other universities the college allowance rises from £212 to £240.

Deadlock All Round

The negotiations to end the London dock strike broke down early this week and no further meetings between the two sides have been planned. The London bus strike entered its sixth week with no prospect of an immediate settlement. The vital difference between the two lies in the attitude of the Transport and General Workers Union, for in the case of the docks the union officials are trying to convince the men to go back. The strike originated in support of the 1,700 Smithfield meat drivers which, the union says, was "contrary to union policy for road haulage workers." Nearly 20,000 men are on strike, 118 ships idle, and London's food supplies threatened.

Seen in the context of the bus strike, where the union are calling for support from London tube workers, the following statement made to the dockers by one of their union officials makes strange reading: "You men are once again carrying the baby for another industry," he said, "and it is time we considered our own problems and wage claims. We keep getting involved in disputes over which we have no control." The response from the tube workers to a call for a token support strike each Monday was only of 10 per cent. But Mr. Cousins continues defiant. He said the men would go back to work only when they had won, and that they were far from being beaten yet. The main point at issue remains the union's refusal to admit Government interference in wage negotiations. They will not accept the principle that wage increases can be refused if there is an increase in the cost of living. Mr. Cousins says they are fighting for the whole trade union movement. But union opinion remains split—and the split appears to be widening.

Continuing **The Human Element**

OPERATOR TRAINING

A Scheme and its Results

By E. D. Simmons, A.M.I.MECH.E., A.M.I.PROD.E.
Training Officer,
Guest Keen and Nettlefolds (Midlands) Ltd.

Some years ago, Guest Keen and Nettlefolds (Midlands) Limited (a wholly-owned subsidiary of the Guest Keen and Nettlefolds group of companies), introduced special methods of training for the operators in their Screw Division. At the end of a five-year period a report on progress was presented to the company's training committee. It is on this report that the following article is based.

There are three main manufacturing units in the G.K.N. Screw Division, St. George's Mill, Heath Street Mill and Imperial Mill, all on the Birmingham/Smethwick boundary, and there are also two smaller outlying factories. The products of the Division include wood screws, bolts, nuts and rivets (both standard and special-purpose), cotter pins, hooks and eyes, automobile engine push-rods and throttle linkages. Heading, slotting and thread forming or cutting are the main types of operation carried out, and labour is needed for single-purpose machines (such as electrical upsetters), multi-purpose machines (capstan lathes, for example), and for group machine jobs where one operator looks after several machines such as automatic slotters or thread cutters. A certain amount of hand work is also necessary. The Division employed, in 1957, 1,014 skilled and 1,524 semi-skilled or unskilled men, and 1,577 women, all semi-skilled. In addition, there are 610 men and 528 women staff employees.

Responsibility for all training matters within the Division rests with a training committee, which consists of the chief engineer (a director of the company), the production director, the personnel officer and a senior works manager. The training officer is secretary to the committee, and Mr. W. Douglas Seymour, of Clent, Worcestershire, acts in an advisory capacity on training.

TRAINING NEEDS

More attention than ever before in the long history of G.K.N. is now being paid to training and this work is based on the realisation that, in spite of mechanisation, the skills of the so-called unskilled or semi-skilled workers are still of crucial importance to productivity. The Division's work is specialised, and there is little work of a similar nature done in the district; thus there is no local pool of experienced labour. This fact, coupled with the high rate of labour turnover in the area, has emphasised the need for rapid training of new entrants. Again, in order to cope with technological changes in the last five years—the introduction of new types of machines, new techniques, and new products—operator training courses for all the principal production operations have had to be developed for re-training existing workers. Attention has, therefore, been devoted just as much to the training of existing workers as to the training of new ones.

Training, besides teaching the actual job, can give a gradual introduction to industrial conditions, which will "acclimatise" the employee by the time he or she is ready to go on production work. Another factor in the new employee training programme was the fact that more workers were needed because of the introduction of double shift working in some sections of the works. Re-training of existing personnel can be necessary not only because of the introduction of new machines or techniques; it can arise out of a need to raise the earnings of operators in a particular type of work. An example of the latter is screw "wrapping," that is, counting, boxing and packing, some of which is done by hand. Training was introduced into the wrapping section to meet the request of the trade unions that girls on this operation should be enabled to earn higher wages. The problem was solved by means of motion study, and training was needed to get the new technique going. From the production point of view training was required to increase output, and to improve quality, and this involved both better methods of using existing equipment, and the introduction of new machines and techniques. On the production side due attention was also given to the introduction of quality control, and to improving safety measures.

PLANNING AND INSTRUCTING

Operator training has been planned to meet the needs of the business by training the right number of workers according to the amount of work available. Training is carried out in small centres adjacent to the main mills, conditions being similar to those in the main production shops. A small quiet room is provided in the training centre where necessary. Some part of the final training may be completed in the production shops, owing to the cost of the equipment involved.

The training is normally carried out by instructors who are themselves experienced workers, and the selection and training of these instructors is given particular care. Vacancies are filled only from within the organisation. When they are appointed, the instructors are given a period of training, full use being made of the courses run by the Ministry of Labour and National Service at Letchworth. In addition, specialised training is given within the Division, and new instructors, before taking up their duties in their own training centre, are allowed to work for a time in a different centre.

In the training centres, the knowledge and skills required for the job are determined, and the skills of experienced operators are analysed, the use of the senses being studied as well as the movements involved. If the analysis shows that there are special difficulties in the job, preliminary training exercises and devices are designed. Then the job is divided into parts suitable for training purposes, special attention being paid to those parts which require greater use of the senses or the making of decisions. Trainees practise the preliminary exercises first, then go on to practise parts of the job. When they are as proficient in each part of the job as an experienced worker, they attempt one cycle of the complete operation. Periods of practice on the whole job are then progressively increased until the trainee can maintain the desired standard of output and quality for a day, and later for a week.*

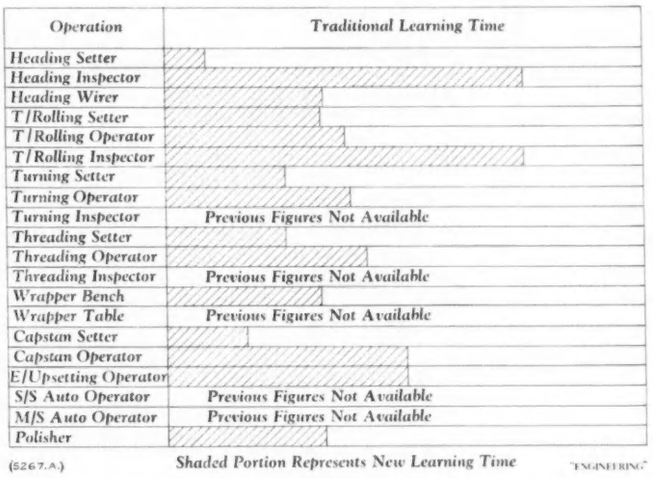


Fig. 1 Reduction in learning time on operations for which specialised training is provided.

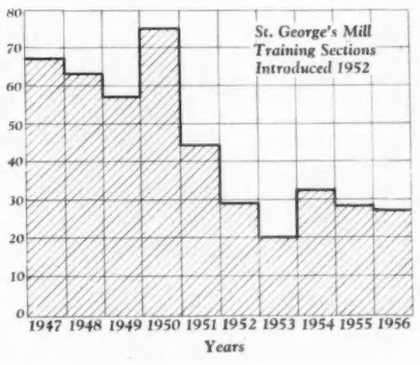


Fig. 2 Labour turnover (female).

ACHIEVEMENTS

Any training scheme can only be judged, ultimately, by what it achieves, and this may be

* This training procedure is dealt with in greater detail in "Training Operators for the Engineering Industry," by W. Douglas Seymour, ENGRG. vol. 182, p. 2 (1956).

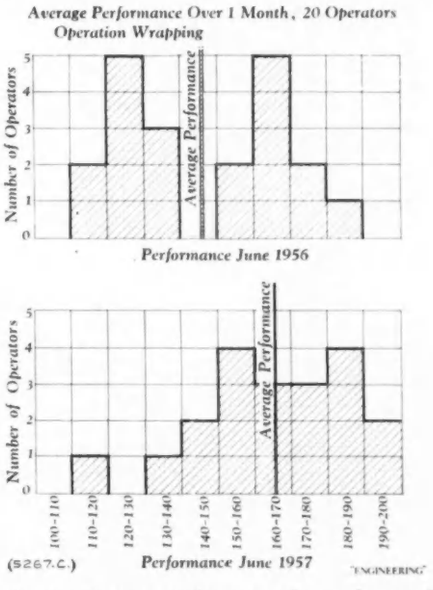


Fig. 3 Operator performance: day work rate of performance = 100.

Continuing The Human Element

difficult to determine accurately, since factors other than training may be involved. For this reason the facts quoted in what follows refer either to the training itself, or to circumstances in which operator training is the only item which has been changed.

In the actual training itself specialised methods have reduced the time taken for trainees to reach an experienced worker's standard. This is illustrated, for several types of work, by Fig. 1. Labour turnover has been reduced considerably since the introduction of systematic training, as shown by Fig. 2, which represents a section of the works where a high labour turnover was formerly the rule.

How training increased operator performance is shown by Fig. 3, which represents conditions in the screw wrapping room. It will be seen that if the day work rate of performance is taken as 100, the average operator performance before training was 141, while after training it rose to between 165 and 168. This increase in output saved the recruitment, training and supervision of 10 extra operators, and was accompanied by a rise in the workers' earnings. It was achieved by training new operators to work at a 150 performance and by re-training existing operators whose performance was consistently below 140.

Quality of work is emphasised throughout the training programme by the fault analysis procedure; an initial talk on the correct attitude to faults being followed by detailed analysis of poor quality work under the headings—name of fault, appearance, cause, effect, responsibility, action and prevention. As Fig. 4 shows, this method of training can result in some worthwhile improvements in the scrap returns. "Good housekeeping" and safety are also given due attention in the training programme, and while it is difficult to measure the effectiveness of this work accurately, it is true that a reduction in accidents has taken place since training began. Fig. 5 shows the accident frequency among female operatives in a typical section of the works.

FLEXIBILITY

Specialised training has proved advantageous in many ways besides those already mentioned. The introduction of new machinery, for example, had presented many problems in the past, and it was decided in 1952 that the first batch of new machines should be installed in the training centres instead of in the production shops, and that all operators should be given comprehensive training on the new machines for two or three weeks before being asked to work them on production. The first two trainees were workers

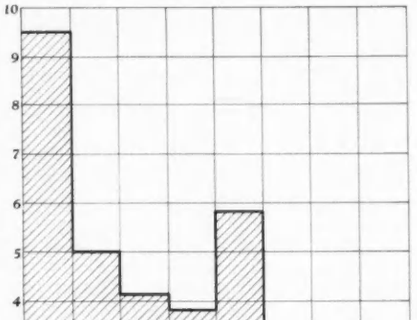


Fig. 4 Bolt scrap returns January to August, 1957.

who had joined the company in 1913 and 1914, respectively, and they passed the training course successfully.

Re-training has not only been used in connection with new machines, it has proved equally successful with new methods, and it has been applied for training operatives to do different work when there was any trade slackness in their own special type of job. It is, in fact, a deliberate policy to train operators in more than one type of job, and the versatility of these workers has proved an asset.

The mental reactions of various parties to the training scheme have all been favourable. New workers appreciate the opportunity to reach piecework level quickly, and experienced hands co-operated well, knowing that they would be relieved of training responsibilities, and would run no risk of reduced earnings. Trade union opinion has found the training scheme acceptable, and union help has been given freely. The Division's employment officer has reported that the facilities offered by the training department are a help in attracting the right type of labour.

COST OF TRAINING

The wrapping section, where the method of training is the only factor of change, provides a

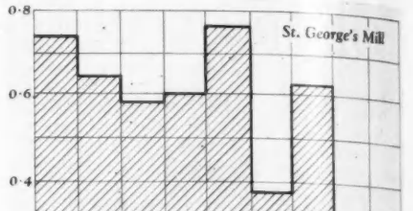


Fig. 5 Accident frequency.

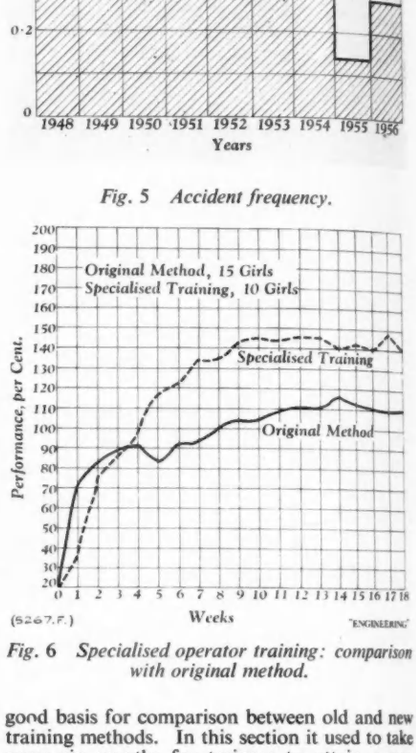

Original Method, 15 Girls
Specialised Training, 10 Girls
Specialised Training
Original Method
Performance, per Cent.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Weeks
(5267.F.)
"ENGINEERING"

Fig. 6 Specialised operator training: comparison with original method.

good basis for comparison between old and new training methods. In this section it used to take some six months for trainees to attain a performance of approximately 130. Trainees now reach a performance of 140 to 150 in about eight weeks. Fig. 6 shows the old and new training times graphically. Such an improvement in the time taken to train workers will obviously reduce the cost of training. In this particular instance the economy is more than £50 per trainee.

NOTICES OF MEETINGS

British Computer Society

LONDON
Annual General Meeting and Presidential Address. Northampton College of Advanced Technology, St. John Street, E.C.1. Mon., 16 June, 5.30 p.m.

Institution of Electrical Engineers

LONDON
Institution Conversazione, Royal Festival Hall, S.E.1. Wed., 25 June, 7.30 p.m.

Institution of Mechanical Engineers

CARDIFF
"Light Mechanical Engineering in South Wales," by H. A. V. Bulleid; and "Some Mechanical Equipment in the Heavy Industries of South Wales," by W. F. Cartwright and I. S. Scott-Maxwell. Ordinary Meeting of the Institution. Rearden Smith Lecture Theatre, Cardiff. Wed., 18 June, 10 a.m.

Institution of Public Health Engineers

LONDON
Summer Meeting. Annual General Meeting, at 4.45 p.m. Tea at 5.15 p.m. Discussion on "The Hogsmill Valley Sewage Treatment Works," by J. T. Calvert, at 6 p.m. Caxton Hall, off Victoria Street, S.W.1. Fri., 13 June. (A visit to the Hogsmill Valley Works, near Surbiton, Surrey, will be paid on Saturday morning, 14 June.)

Royal Meteorological Society

LONDON
Various short papers including "The Use of Balloons in Atmospheric Pollution Research," by D. H. Lucas, G. Spurr and F. Williams; and "The Hydrogen Content of Atmospheric Air at Sea," by E. Glueckauf and G. P. Kitt. Wed., 18 June, 5 p.m.*

Royal Society of Health

SOUTH SHIELDS
Various papers including "Pollution of Tidal Waters, with Special Reference to the River Tyne," by Dr. T. L. Coxon. Town Hall, South Shields. Wed., 18 June, 10 a.m.

Women's Engineering Society

LONDON
Annual General Meeting. London Branch. Headquarters of the Central Electricity Generating Board, Winsley Street W.1. Wed., 18 June, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1. (SLOane 5134.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

Marketing

CREDIT FOR SELLING AIRCRAFT

The difficulties of selling British aircraft overseas were discussed in a statement from the Society of British Aircraft Constructors dealing with credit terms. "Selling airliners abroad," they say, "is no longer a matter of simply proving one product's superiority over a competitor's." Mr. W. E. Nixon, chairman and managing director of de Havilland Holdings, is quoted as saying that the struggle of the world's airlines "to make ends meet" has led to "considerable competition as regards terms of payment." The handicap of British aircraft firms in being unable to supply long-term credits is hard to overcome and SBAC clearly hope for Government assistance. A Government committee is at present studying the problem and Mr. Nixon expressed the hope "that as a result of this study, Government action may be taken to help remove these disadvantages."

The implications of any Government assistance, if it is to be effective, is the provision of money cheaper than is currently available. As SBAC point out, it is a country's economic situation which determines whether money is dear or cheap. In the United States it is much cheaper and the aircraft companies are therefore in a position to make long-term loans at relatively very low rates. In addition, they have found it possible to make substantial "trade-in" allowances for old aircraft, as have Boeing and Lockheed. But the ability to do this, or to give long-term credit, depends on great financial strength as well as on the availability of cheap money. To some extent the British industry could help itself by concentrating its available resources, but Government assistance and backing will also be required.

Lisbon Fair

The Federation of British Industries have decided that the next British Trade Fair in their programme of overseas fairs will be held in Lisbon from 29 May to 14 June next year. It will be organised by British Overseas Fairs Limited, the subsidiary of the FBI which was responsible for the organisation of the trade fairs held in Baghdad in 1954, Copenhagen in 1955 and Helsinki in 1957, as well as the British Pavilion at the Damascus International Fair in 1956 and the British Industry Pavilion at the Brussels Universal and International Exhibition.

For many years Britain has been Portugal's main customer and, until recently, her main supplier. Germany has now taken the lead though she buys comparatively little in Portugal. The FBI feel that "the time is ripe for a special endeavour by British industry to regain its position" and hope this might result in a swing of trade to this country of some £5 million to £6 million a year. The fair will be an all-British affair, taking up 125,000 sq. ft of space in and around the new Exhibition Hall in Lisbon. Buyers will be encouraged to come from the whole of South West Europe.

Sales to Eastern Europe

Efforts by British companies to promote the sale of their products in Soviet bloc countries are increasing and meeting with more success. The orders placed by Poland for automatic high-speed lamp-making machinery with Luxram Electric Limited and by Hungary for J. Stone's railway carriage air-conditioning equipment are recent examples. In Stone's case there is a reasonable prospect that the equipment will be accepted as standard by Soviet Russia and will be made under licence in Poland after the first 100 sets have been delivered.

The United Construction Machinery Company Limited, which represents the major British manufacturers of contractors' plant and machinery, are holding a joint exhibition at the Poznan Fair this month to secure maximum advantage from what their chairman, Mr. W. M. Robb, called "these relatively new export markets." Pointing out that British construction machinery holds the lead in Europe, Mr. Robb said that considerable competition is growing in Poland and other countries in the Eastern bloc. If British manufacturers did not grasp their opportunities, he stressed, "using all the imagination and initiative of British salesmanship," most of the business will be lost to Germany, France, Sweden, Belgium and Italy. U.C.M.C. have demonstrated the success of a co-operative approach to marketing problems.

Handled Well

The organisers of the Mechanical and Materials Handling Convention (held last month at Earls Court) have announced that it has been more successful than on any occasion since it was started in 1948. Buyers from over 70 countries passed through the overseas reception centre and attendance was not adversely affected by the bus strike or by the threatened rail strike. In his statement the organiser, Mr. H. A. Collman, reported that he had had "many glowing commendations from a business point of view," and that several exhibitors had already asked for double their floor space for the next exhibition in 1960.

A major factor in the exhibition's success was its international character. For the first time visitors had an opportunity to compare products made in this country with some of those from abroad and there was a large increase in the number of overseas visitors. Among the special developments which attracted most interest were conveyors which are rapidly expanding their uses in industry. The application of electronic controls to conveyors and of ancillary electronic equipment—for sorting, weighing, batching and inspection of materials—has doubtless widened the scope of conveyors considerably. The success of the exhibition and the technical advances it revealed suggest that sales promotion could achieve much more for the industry than it has done so far.

Caravans through the Curtain

The marketing activities of the instrument industry have become intensified in recent months, particularly in export markets (as discussed in the note on SIMA on this page). Kelvin Hughes have themselves begun a major sales drive in Europe and are currently touring both Western and Eastern European markets with mobile demonstration units. They have equipped two caravan units with specialised equipment, one for marine applications and the other for industrial applications.

The marine caravan contains marine radar equipment which incorporates several new features such as printed circuits and potted components. There is also a range of echo sounding equipment for fish finding and ancillary small equipment such as binoculars, telescopes, sextants, etc. The industrial caravan carries high-frequency recording equipment, including strain recording apparatus for use in the mining and weaving industries, equipment for ultrasonic flaw detection, gas analysis and electro-medical applications.

The caravans will start their tour in Poland, and visit Czechoslovakia, Hungary, Rumania, Yugoslavia, Italy, Western Germany and Belgium. This is the sequel to previous successful demonstration tours in this country where the marine caravan has already visited "practically every seaport of note."

Getting Together

The marked success during the past few months of co-operative selling in overseas markets by engineering companies whose products are complementary has been the subject of frequent comment in these columns. It has been particularly marked in Eastern Europe, where there exists usually only one "monopoly" buyer with close government affiliations. Increasingly, conditions in world trade favour co-operative efforts, whether to provide service facilities in North America, long-term credit in India, a unified voice in Poland or a comprehensive engineering scheme in Russia. Co-operative efforts overseas, are likely to multiply, particularly if the medium and small firms in the engineering industry are to play their parts in export markets. The Dollar Exports Council have preached this long and hard in respect of North American trade and their message is gradually having its effect.

The new announcement by Shell Petroleum that orders for electrical equipment had been placed with seven British firms in connection with the construction of a large new oil terminal at Puerto Miranda in Venezuela is yet further evidence of the scope which exists for co-operative tendering, though in this case some of the companies concerned are competitors elsewhere. The companies involved are: South Wales Switchgear, Reyrolle, British Thomson-Houston, C. A. Parsons, English Electric, Crompton Parkinson, and British Insulated Callender's Construction.

In this case foreign companies are also involved —three 20 MW gas-turbo generators costing nearly £2 million are being obtained, one from the United States and two from Switzerland— and there is no evidence that the orders for British firms were secured by group tendering. Yet such large schemes are ideally suited to a group approach whereby varying skills and specialities are blended to provide the customer with a fully engineered project.

Promoting British Instruments

One of the most promising of co-operative export promotion efforts made so far is rapidly gathering momentum. The Scientific Instrument Manufacturers' Association of Great Britain (SIMA) have recently increased their efforts both in Europe and North America and have succeeded in attracting widespread interest. The success of their members at last year's INTERKAMA at Düsseldorf and the good results obtained from the international Instruments, Electronics and Automation Exhibition at Olympia earlier this year have made member firms exhibition-minded to a much greater extent than they were. Seven firms are currently exhibiting at the European Exhibition and Congress of Chemical Engineering (ACHEMA) at Frankfurt and are putting on a very good show of what SIMA describe as "unequalled British scientific instrumentation developments in optics, electronics, nucleonics and laboratory equipment."

SIMA have also begun a drive to make the industry's products better known to industrial users and scientists in Canada. The resident Minister (Commercial) at Canada House, Mr. Leslie Brown, was present at SIMA's annual luncheon, together with representatives from many other countries. More information on new developments in British instrumentation has been sent to Toronto following the interest created by the visit of a SIMA team to Toronto, Ottawa and Montreal on a "fact finding tour" under the leadership of Mr. Laurie Woodhead of Cossor Instruments. SIMA's president, Mr. Paul Goudime, has recently stressed the industry's determination to meet the future demands of the Commonwealth as well as those of countries in the common market and European Free Trade areas.

Research and Development

INFLUENCE OF STRAIN HARDENING ON THE DILATION OF CYLINDERS UNDER INTERNAL PRESSURE

By E. Voce, PH.D., M.SC., F.I.M. *Senior Metallurgist, Copper Development Association*

Though many authorities have discussed the dilation of metallic cylinders under internal pressure, few have considered in detail the influence of strain hardening. A notable exception is Manning,[1] who proposed a method of empirical integration to assess its effect.

In 1948 it was shown that the strain hardening of metals and alloys can be represented over a considerable range of deformation by a simple exponential equation,[2] the validity of which has been amply confirmed by subsequent work.[3] With the help of this information it is possible to carry out with ease the integration which Manning performed by a laborious arithmetical technique, and it is the purpose of the present article to show how it can be done.

During dilation, strain hardening gradually strengthens the cylinder wall while progressive thinning effectively weakens it. In consequence, the pressure-dilation curve reaches a maximum, after which the wall may bulge locally and finally burst, just as a tensile specimen necks and breaks after passing the maximum load. Though qualitatively allied, the two maxima are not directly related to each other, and it is impossible to calculate the bulging pressure of a cylinder from a knowledge of the tensile strength and dimensions alone. Nevertheless, the analysis to be described enables the bulging pressure to be found from the strain hardening characteristics of the material.

Two solutions are offered. The first embraces full integration across the thickness of the wall, while the second is an approximation which is easier to handle and perfectly satisfactory for most practical purposes.

The experimental results of Crossland and Bones[4] have been analysed by both methods, together with certain data on copper tubes made available through the courtesy of the British Oxygen Company.

SYMBOLS AND DEFINITIONS

The symbols to be used are listed and described in Table I; they will be introduced into the text with a minimum of further explanation.

Throughout the paper, the word "*stress*" signifies true stress, or load divided by the instantaneous sectional area. The tensile strength will always be referred to as such; being calculated upon the original sectional area, it is not a stress in the sense just defined. Similarly the word "*strain*" invariably means the true, or logarithmic strain of Ludwik, and is not to be confused with an ordinary fractional increment. It is, however, frequently convenient to use the simple *deformation ratio*, which is merely the exponential (*i.e.*, natural antilogarithm) of the strain. These conceptions will be clarified by reference to Table I.

TABLE I.—*Symbols.*

("Stress" invariably means true stress, and "strain" true logarithmic strain.)

	Dimensions of Cylinders
R_0 R	External radius before and after dilation
r_0 r	Internal ,, ,, ,, ,,
x_0 x	Any ,, ,, ,, ,, ,,
	Size Ratios
k_0 k	Size ratio before and after dilation; $k = \frac{R}{r}$
k_b	,, ,, at bulging point (incipient failure)
	Deformation Ratios
ρ_R ρ_r ρ_x	Deformation ratio at radius indicated by suffix; $\rho_x = \frac{x}{x_0}$
ρ_a	Thickness ratio, or deformation ratio at average radius.
	Strains
η_R η_r η_x	Strain at radius indicated by suffix; $\eta_x = ln\, \rho_x$
η_a	Thickness strain, or strain at average radius
	Principal Stresses and Strains
s_1 s_2 s_3	Principal stresses, circumferential, axial and radial
η_1 η_2 η_3	Principal strains, ,, ,, ,,
α	Modulating factor for stress in respect of yield criterion
β	Modulating factor for strain in respect of yield criterion
	Yield Stresses
S S_R S_r S_x	General and local values of instantaneous yield stress
S_b	Bulging stress (incipient failure)
	Strain Hardening Constants
S_0	Threshold stress; initial value of yield stress
S_∞	Asymptotic stress; yield stress after severe deformation
η_c	Characteristic strain
	Tensile Properties
S_m η_m	Critical (true) stress and strain at maximum load in tension
T_m	Tensile strength (not a true stress); $T_m = S_m\, exp\,(-\eta_m)$
	Torsion Properties
τ τ_{12}	Shear stress, and its chief principal value; $2\tau_{12} = S_1 - S_2$
γ γ_{12}	Shear strain, and its chief principal value; $\gamma_{12} = \eta_1 - \eta_2$
	Pressures
P	Pressure at which wall of cylinder yields
P_b	Bulging pressure (incipient failure)
	General
X y	Variables in generalised functions

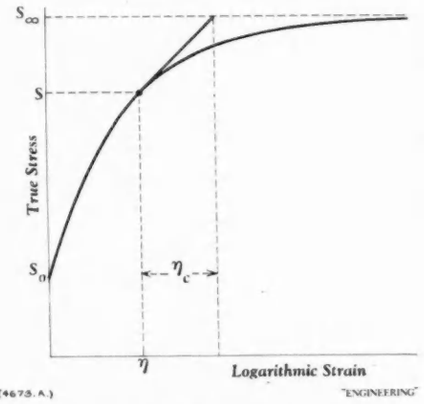


Fig. 1 Diagrammatic representation of the exponential strain-hardening function.

Elastic components of strain are small in comparison with the strains under consideration, and have been neglected. It follows that the volume of the material is assumed to remain sensibly constant during dilation of the cylinder and that Poisson's ratio, in terms of logarithmic strain under uniaxial deformation, can be taken as $\frac{1}{2}$.

Incipient failure, with possible local bulging, occurs when the internal pressure reaches its maximum value; this will be referred to as the *bulging pressure*. A cylinder does not necessarily burst immediately on reaching the bulging point, particularly in the case of ductile materials, to which attention is primarily directed.

STRAIN HARDENING FUNCTION

The material comprising the cylinder wall will be assumed to behave in an isotropic manner, and to conform to the exponential strain hardening function, which for uniaxial deformation (simple tension or compression) can be expressed in the form

$$S = S_\infty - (S_\infty - S_0)\, exp\left(-\frac{\eta}{\eta_c}\right). \quad (1)$$

The significance of the three constants of this equation will be appreciated from Fig. 1, in which the corresponding curve is plotted diagrammatically. The *threshold stress*, S_0, is that at which essentially plastic deformation begins, while the *asymptotic stress*, S_∞, is that attained after severe deformation. The *characteristic strain*, η_c, is the (constant) strain which would be required to raise the stress from any point on the curve to the asymptotic value along the tangent at the point in question.

For large deformations, generally greater than those involved in the dilation of cylinders under internal pressure, the strain-hardening function merges smoothly into a second regime of the same form but for which the constants have larger numerical values. Moreover, the initial part of the strain-hardening curve is connected to the elastic line through a short curved fillet, due to the fact that all parts of the material do not enter upon plastic deformation at the same instant. The fillet is normally so small that it can be left out of consideration, provided that an appropriate value is taken for the threshold stress, S_0.

Authorities agree that a cylinder dilating under internal pressure does not sensibly alter in length, and the conditions are therefore those of plane strain. In order to modulate from uniaxial deformation to plane strain (with or without a superimposed "hydrostatic" stress) it is necessary to multiply the observed stress and strain by numerical factors defined by the criterion of plastic flow adopted. It is apparent from equation (1) that this is tantamount to multiplying the two stress constants and the characteristic strain by the reciprocals of these factors. Calling the reciprocal factors α and β respectively, the equation for plane strain becomes

$$S = s_1 - s_3 = \alpha\left[S_\infty - (S_\infty - S_0)\, exp\left(-\frac{\eta}{\beta\,\eta_c}\right)\right] \quad . \quad . \quad . \quad (2)$$

The criterion of yield which governs the numerical values of the modulating factors remains a matter of controversy. According to the widely quoted octahedral shear criterion, the stress factor is $\frac{\sqrt{3}}{2}$, and the corresponding strain factor $\frac{2}{\sqrt{3}}$, so that α and β are respectively the reciprocals of these quantities. The maximum shear stress is, however, the same whether under conditions of uniaxial deformation or plane strain,

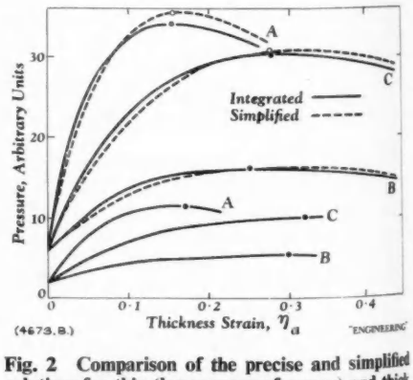


Fig. 2 Comparison of the precise and simplified solutions for thin (lower group of curves) and thick cylinders in three hypothetical materials with the strain-hardening properties given in Table II.

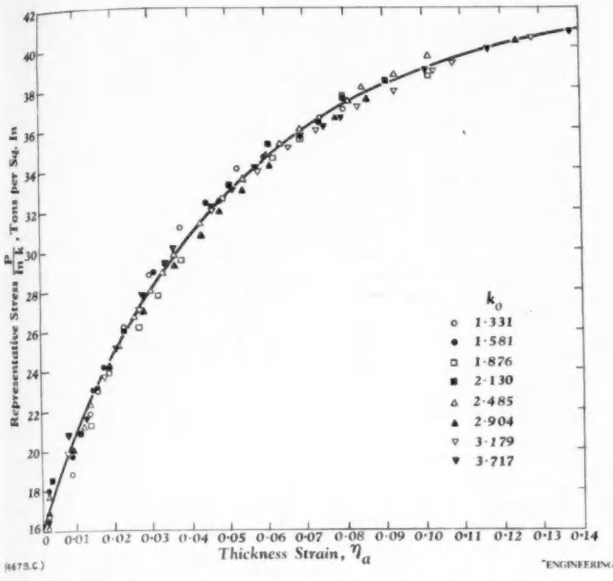


Fig. 3 (left) Strain hardening curve obtained from the dilation data of Crossland and Bones by applying the simplified solution inversely.

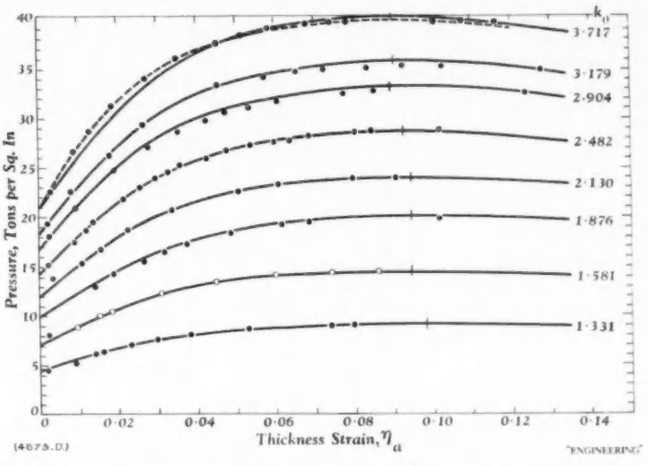


Fig. 4 (above) Dilation curves reconstructed by means of the simplified solution from the strain-hardening constants derived from Fig. 3.

and, by the maximum shear criterion, α is consequently unity. But the corresponding maximum shear strain is $\eta_1 - \eta_3$, which for plane strain becomes $\eta_1 - (-\eta_1) = 2\,\eta_1$, whereas for uniaxial deformation it is only $\eta_1 - (-\frac{1}{2}\,\eta_1) = \frac{3}{2}\,\eta_1$. It follows that for the same measured value of the chief principal strain, η_1, the shear under plane strain is $\frac{4}{3}$ times that for uniaxial deformation, and the value of β is consequently $\frac{3}{4}$. While most authorities prefer the octahedral shear criterion, the experimental work to be later described appears to favour the maximum shear criterion. The choice will therefore be left open by retaining the algebraic symbols, and regarding the composite quantities, $\alpha\,S_0$, $\alpha\,S_\infty$ and $\beta\,\eta_c$ as the strain hardening constants applicable to the subject in hand. When determined from pressure-dilation curves or from torsion tests, both of which are cases of plane strain, the composite constants are obtained directly; only if it is desired to modulate to uniaxial deformation, in order, for example, to correlate with the ordinary tensile properties of the material, is it necessary to know, or to deduce, the factors.

SIZE RATIOS AND STRAINS

It is conventional in the present context to express the size of a cylinder in terms of the ratio, k, of the external to the internal radius, or diameter. Cylinders with equal size ratios are geometrically similar and behave in the same way, irrespective of their actual dimensions. During dilation, the size ratio, k, diminishes from its original value, k_0, and would reach unity if the deformation became indefinitely great. It is not, however, itself either a deformation ratio or a strain.

In normal circumstances the degree of dilation can be assessed most conveniently by measuring the increase in the external radius or diameter. The external dilation ratio is $\rho_R = \dfrac{R}{R_o}$, while the strain at the outer surface is the natural logarithm of this quantity. Similar definitions apply to the strain at the inner surface, and to that at any particular annulus within the wall (see Table I).

Because the length of a dilating cylinder does not alter, the sectional area of the wall, or any part of it, must remain unchanged. This fact is embodied in the equation

$$R^2 - R^2{}_0 = x^2 - x^2{}_0 = r^2 - r^2{}_0 \quad . \quad (3)$$

from which it can be shown that

$$\rho_R = \sqrt{\frac{1 - k_o^{-2}}{1 - k^{-2}}} = \frac{k}{k_0}\,\rho_r \quad . \quad (4a)$$

or, in logarithmic form,

$$\eta_R = ln\,\rho_R = \tfrac{1}{2}\left\{ln\,(1 - k_0^{-2}) - ln\,(1 - k^{-2})\right\} \quad . \quad . \quad . \quad (4b)$$

Moreover, also from equation (3),

$$k = \sqrt{\frac{1 - \rho_r^{-2}}{1 - \rho_R^{-2}}} \quad . \quad . \quad (5a)$$

or,

$$ln\,k = \tfrac{1}{2}\left\{ln\,(1 - \rho_r^{-2}) - ln\,(1 - \rho_R^{-2})\right\} \quad (5b)$$

From equations (4b) and (5b) it is evident that a graph of the generalised function $y = \frac{1}{2}\,ln\,(1 - X^{-2})$ provides a ready means of interconverting size ratios and strains. For example, from equation (4b), η_R is simply the difference in the values of y for $X = k_o$ and $X = k$, while, from equation (5b), the difference in the values of y for $X = \rho_r$ and $X = \rho_R$ instantly gives $ln\,k$. Such a graph can easily be constructed, and, plotted on an open scale, will be found greatly to expedite calculations.

Neither at the outer, nor at the inner surface is the dilation representative of the deformation of the wall as a whole. For some purposes it is more satisfactory to use the change of thickness, defined by the ratio $\rho_a = \dfrac{(R_0 - r_0)}{(R - r)}$. Factorisation of equation (3) shows this to be identical with the deformation ratio on the instantaneous average radius, namely $\rho_a = \dfrac{(R_0 + r_0)}{(R + r)}$. Interpreting equation (3) in the light of this definition of representative deformation, it can be shown that

$$\rho_a = \sqrt{\frac{k + 1}{k - 1}\cdot\frac{k_0 - 1}{k_0 + 1}} \quad (6a)$$

while the corresponding logarithmic strain is

$$\eta_a = ln\,\rho_a = \tfrac{1}{2}\left\{ln\frac{k + 1}{k - 1} - ln\frac{k_0 + 1}{k_0 - 1}\right\} \quad (6b)$$

From equation (6b) it is apparent that a plot of the generalised function $y = \frac{1}{2}\,ln\,\dfrac{X + 1}{X - 1}$ can be used to determine the representative thickness strain from a knowledge of the initial and final size ratios in the manner already described, or conversely to find the final size ratio, k, from a knowledge of the initial size ratio, k_o, and the strain η_a. It is recommended that such a graph be constructed as an aid to practical calculations.

The foregoing relationships reveal the essential interconvertibility of size ratios, deformation ratios and strains, and with their help it is possible to express the solutions which follow in terms of any of these parameters at will. The forms in which they will be given are, however, considered to be those which are at once the most informative and convenient.

FULLY INTEGRATED SOLUTION

The basic equation connecting the stresses on an indefinitely thin annulus concentric with the axis of the cylinder is well known. In terms of the symbols defined in Table I it is

$$-ds_3 = (s_1 - s_3)\frac{dx}{x} \quad . \quad (7)$$

The element of radial stress, $-ds_3$, when integrated between the inner and outer radii must balance and oppose the internal pressure, P, at which the wall just yields. Therefore, substituting for $(s_1 - s_3)$ from equation (2),

$$P = \alpha\int_r^R \left[S_\infty - (S_\infty - S_0)\,exp\left(-\frac{\eta_1}{\beta\,\eta_c}\right)\right]\frac{dx}{x} \quad (8)$$

The chief principal strain, η_1, on the annulus under consideration is $ln\,\dfrac{x}{x_0} = ln\,\rho_x$, so that

$$exp\left(-\frac{\eta_1}{\beta\,\eta_c}\right) = \rho_x^{-\frac{1}{\beta\eta_c}} = (\rho_x^{-2})^{\frac{1}{2\beta\eta_c}} \quad . \quad (9)$$

Moreover, from equation (3),

$$\rho_x^{-2} = 1 - (R^2 - R_0^2)\,x^{-2}$$

whence it can be shown that

$$dx = \frac{d(\rho_x^{-2})}{2\,(1 - \rho_x^{-2})} \quad . \quad . \quad (10)$$

Putting equations (9) and (10) into equation (8), and adjusting the limits

$$P = \frac{\alpha}{2}\int_{\rho_r^{-2}}^{\rho_R^{-2}} \left[S_\infty - (S_\infty - S_0)\,(\rho_x^{-2})^{\frac{1}{2\beta\eta_c}}\right]\frac{d(\rho_x^{-2})}{1 - \rho_x^{-2}} \quad . \quad . \quad . \quad (11)$$

the solution of which is

$$P = \alpha\left[S_0\,ln\sqrt{\frac{1 - \rho_r^{-2}}{1 - \rho_R^{-2}}} + (S_\infty - S_0)\left\{\frac{\rho_R^{-2} - \rho_r^{-2}}{2} + \frac{\rho_R^{-4} - \rho_r^{-4}}{4} + \frac{\rho_R^{-6} - \rho_r^{-6}}{6} + \ldots + \frac{\rho_R^{-2n} - \rho_r^{-2n}}{2\,n} + \left(\frac{1}{2\,\beta\,\eta_c} - n\right)\frac{\rho_R^{-2(n+1)} - \rho_r^{-2(n+1)}}{2\,(n + 1)}\right\}\right] \quad . \quad . \quad . \quad (12)$$

where n is the integer equal to or next beneath $\dfrac{1}{2\,\beta\,\eta_c}$, so that $\dfrac{1}{2\,\beta\,\eta_c}$ lies between n and $(n + 1)$. The final term represents a correction for the fact that $\dfrac{1}{2\,\beta\,\eta_c}$ is rarely an integer, and is based on an increment in direct proportion to the fraction part by which $\dfrac{1}{2\,\beta\,\eta_c}$ exceeds n. In most cases the correction is quite small and this procedure is perfectly adequate, but if greater precision is desired, the progressive total of the

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series can be plotted against the integers 1, 2, 3, ... n, $(n + 1)$, when the exact value corresponding to $\frac{1}{2\beta\eta_c}$ can be obtained from the resulting smooth curve by interpolation between the totals for n and $(n + 1)$.

With the help of equations (4) and (5), equation (12) can be expressed in terms of the original and current size ratios, k_0 and k, instead of the deformation ratios. In particular the preliminary term becomes $\alpha S_0 \ln k$. Moreover, the series is essentially the expansion of $\ln k$ curtailed at $\frac{1}{2\beta\eta_c}$ instead of extending to infinity.

In the absence of dilation, the size ratio retains its initial value, k_o, while both ρ_R and ρ_r remain unity, so that the series disappears, leaving

$$P = \alpha S_0 \ln k_o \quad . \quad . \quad (13)$$

This is the result proposed many years ago by van Iterson[5], and represents the conditions of initial yield alone. Moreover if the material does not strain harden so that $(S_\infty - S_0) = 0$, the series disappears even though the cylinder may dilate. In this case van Iterson's equation is also applicable, except that the current value of the size ratio, k, must be used in place of k_0, showing that the yield pressure falls continuously as the wall thins.

The maximum of the pressure-dilation curve at which local bulging and consequent failure may commence can be found by expressing equation (12) in terms of k, differentiating and equating to zero. The result is

$$\frac{\left(\frac{k_0}{k_b}\right)^{\frac{1}{\beta\eta_c}+2} - 1}{\left(\frac{k_0}{k_b}\right)^2 - 1}\left(\frac{k_b^2 - 1}{k_0^2 - 1}\right)^{\frac{1}{2\beta\eta_c}} = \frac{S_\infty}{S_\infty - S_0} \quad . \quad . \quad . \quad (14a)$$

where k_b is the size ratio at which bulging may occur. The modulated stress constants, αS_0 and αS_∞, can be used in this and in the next equation, since the modulating factor clearly cancels out. Equation (14a) can be solved for k_b by trying a few values and finding by interpolation that which gives the result fixed by the right-hand side. The corresponding deformation ratios, ρ_R and ρ_r, follow from equation (4), and the bulging pressure can then be calculated from equation (12).

By converting the size ratios of equation (14a) to deformation ratios through equations (4) and (5), and rearranging, it can be shown that the bulging point occurs when

$$\frac{S_\infty - (S_\infty - S_0)\,\rho_R^{-\frac{1}{\beta\eta_c}}}{\rho_R^2} = \frac{S_\infty - (S_\infty - S_0)\,\rho_r^{-\frac{1}{\beta\eta_c}}}{\rho_r^2} \quad . \quad . \quad . \quad (14b)$$

Each numerator is simply the yield stress on the outer or inner surface respectively. Thus the bulging point is reached when the local yield stress divided by the square of the corresponding deformation ratio is the same at the outer and inner surfaces of the cylinder. By using ρ_x^{-2} as either the lower or upper limit of the integral in equation (11), it becomes evident that this quotient for any intermediate radius is equal to either or both of the terminal values. In other words, the maximum pressure occurs and bulging may begin when the local yield stress divided by the square of the deformation ratio is constant across the cylinder wall. The inference that the criterion of failure is not directly dependent upon the tensile strength of the material is inescapable.

SIMPLIFIED SOLUTION

Simplification can clearly be achieved if it is possible to select a single strain which will be representative of the deformation of the wall as a whole. The corresponding value of the yield stress can then be regarded as uniform across the cylinder wall, and, when put into equation (8), can be treated as a constant for purposes of integration. Theoretically the representative strain should be related not only to the size and deformation of the cylinder but also to the strain hardening properties of the material, for it is these which control the distribution of yield stress across the wall. However, checks against the integrated equation show that very satisfactory results can be obtained by using the thickness strain, or its equivalent, the strain on the instantaneous average radius. Other possibilities have been explored, but none has a better combination of simplicity, credibility and accuracy. On this basis the solution becomes

$$P = \alpha\left[S_\infty - (S_\infty - S_0)exp\left(-\frac{\eta_a}{\beta\eta_c}\right)\right]\ln k \quad (15a)$$

$$= \alpha\left[S_\infty - (S_\infty - S_0)\,\rho_a^{-\frac{1}{\beta\eta_c}}\right]\ln k \quad . \quad (15b)$$

$$= \alpha\left[S_\infty - (S_\infty - S_0)\left(\frac{k-1}{k+1}\cdot\frac{k_0+1}{k_0-1}\right)^{\frac{1}{2\beta\eta_c}}\right]\ln k \quad . \quad . \quad . \quad (15c)$$

The maximum can be found by differentiating with respect to k and equating to zero. After suitable manipulation, it can be shown that the bulging stress, S_b, is given by

$$S_b = \frac{\alpha S_\infty}{1 + \frac{k^2 - 1}{k \ln k}\beta\eta_c} \quad . \quad . \quad (16)$$

A graph of the function $\frac{k^2 - 1}{K \ln k}$ is useful. Conveniently it changes slowly with k, increasing from the limiting value of 2·0 for $k = 1$ to 2·7 for $k = 4$, and for normal purposes it is sufficient to take the known value of k_0 in place of k in equation (16). In this manner an approximate value for the bulging stress S_b can be quickly ascertained. The corresponding strain follows from equation (1), and thence the size ratio k_b from equation (6b). This completes the information necessary to calculate the bulging pressure from equation (15), which reduces to the van Iterson form

$$P_b = \alpha S_b \ln k_b \quad . \quad . \quad (17)$$

It may be remarked that errors in S_b and k_b tend to compensate each other in this equation; the error introduced by substituting k_0 for k in equation (16) is consequently less than might be expected.

Unlike the fully integrated solution, the simplified function can be used inversely to determine the strain hardening constants from a pressure-dilation curve. From equation (15a) it is evident that a plot of $\frac{P}{\ln k}$ against η_a gives a strain hardening curve which can be analysed in the normal manner.[3] The results are subject to the proviso that η_a is at best an approximation to the truly representative strain, but are sufficiently accurate for most practical purposes, except perhaps in the case of very thick cylinders.

COMPARISON OF THE TWO SOLUTIONS

The results given by the two solutions have been compared by constructing the pressure-dilation curves for a moderately thin and a moderately thick cylinder in each of three hypothetical materials with different strain hardening constants. The initial size ratios of the cylinders were respectively $k_0 = \sqrt{2} = 1{\cdot}414$ and $k_0 = \sqrt{10} = 3{\cdot}162$, while the properties of the three materials are given in Table II. The stresses are in arbitrary units, but would be credible in tons per sq. in, 1,000 lb per sq. in or kg per sq. mm. Materials A and B have the same stress constants with small and large characteristic strains respectively, while materials A and C have approximately the same ordinary tensile strengths in spite of the difference in their strain hardening constants.

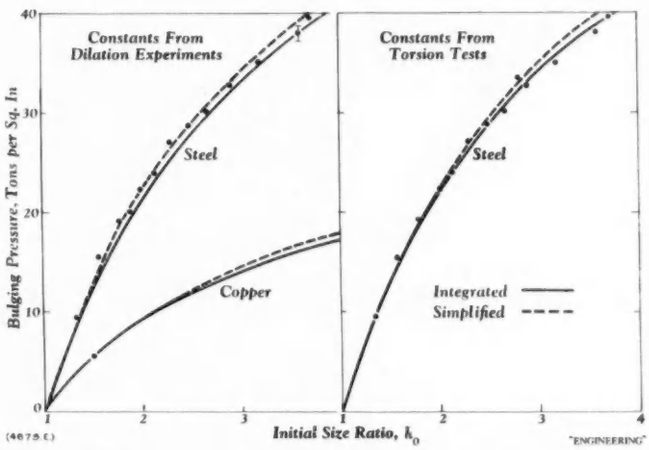

Fig. 5 Bulging pressure curves calculated from the strain-hardening constants derived from: left, dilation experiments; right, torsion tests.

The calculated curves for pressure against thickness strain are shown in Fig. 2, thickness strain being chosen because it is more representative than either the external or internal strain. The bulging points calculated by the two methods are compared in Table III, and are marked on the curves in Fig. 2. For the thinner cylinders, the precise and simplified equations give almost identical results, the curves being indistinguishable on the diagram. For the thicker cylinders, the approximate curves are somewhat too flat in their early stages, and reach maxima which are a little too high. Nevertheless, the simplified solution seems sufficiently accurate for most normal requirements, and is much quicker to handle.

Attention is drawn to the marked difference between the curves for materials A and C which have almost the same tensile strengths. Clearly it is impossible to predict the behaviour of a cylinder of given size from a knowledge of the tensile strength alone.

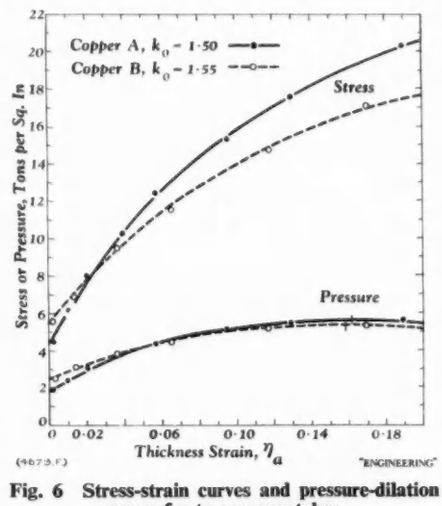

Fig. 6 Stress-strain curves and pressure-dilation curves for two copper tubes.

PRACTICAL EXAMPLES

Crossland and Bones[4] determined the curves of pressure against external dilation ratio for a range of steel cylinders having various initial size ratios. They also performed torsion tests,

TABLE II.—*Properties of Fictitious Materials for Comparison of Precise and Simplified Equations*

(Stresses in arbitrary units, e.g., tons per sq. in, 1,000 lb per sq. in or kg per sq. mm.)

Material designation		A	B	C
Plane Strain				
Threshold stress	αS_0	5	5	5
Asymptotic stress	αS_∞	55	55	110
Characteristic strain	$\beta\eta_c$	0·1	0·5	0·5
Simple Tension (Using maximum shear criterion of yield)				
Threshold stress	S_0	5	5	5
Asymptotic stress	S_∞	55	55	110
Characteristic strain	η_c	0·133	0·667	0·667
Critical stress	S_m	48·5	33·0	66·0
Critical strain	η_m	0·272	0·548	0·582
Tensile strength	T_m	37·0	19·1	36·8
Simple Tension (Using octahedral shear criterion of yield)				
Threshold stress	S_0	4·3	4·3	4·3
Asymptotic stress	S_∞	47·7	47·7	95·4
Characteristic strain	η_c	0·115	0·577	0·577
Critical stress	S_m	42·9	30·3	60·5
Critical strain	η_m	0·254	0·527	0·560
Tensile strength	T_m	33·2	17·9	34·6

TABLE III.—*Comparison of Bulging Points Calculated from the Precise and Simplified Equations*

Co-ordinates of bulging point	Bulging pressure (arbitrary units)		Thickness strain at bulging point	
Equation used	Precise	Simplified	Precise	Simplified
Thin cylinders, $k_0^2 = 2$.				
Material A	11·2	11·3	0·172	0·168
,, B	5·23	5·20	0·295	0·295
,, C	10·0	9·9	0·320	0·320
Thick cylinders, $k_0^2 = 10$				
Material A	34·0	35·6	0·155	0·154
,, B	16·0	16·1	0·252	0·253
,, C	30·3	30·6	0·278	0·277

and used the results to calculate dilation pressures by Manning's arithmetical integration. These data have been analysed by two distinctly different methods of approach; in the first, the strain-hardening constants were found by applying the simplified function inversely to the dilation curves, while in the second they were derived from the torsion experiments.

Analysis of the Dilation Curves.—For each experimental point, the thickness strain, η_a, and the current size ratio, k, were calculated from equations (4) and (6) (suitably rearranged). Division of the pressure by $ln\, k$ then gives the stress-strain curve, which can be analysed in the normal way.[3] Fig. 3 shows that, so treated, all the experimental points lie close to a single curve, the constants for which are recorded in Table IV. The individual pressure-dilation curves regenerated from these constants by means of the simplified function are shown in Fig. 4; they agree satisfactorily with the experimental values.* In the left-hand part of Fig. 5, the curves for bulging pressure against initial size ratio, calculated by both the fully-integrated and the simplified methods are compared with the experimental values. As might be expected from Fig. 2, the simplified function gives slightly the higher pressures; the maximum discrepancy is, however, no more than 3·6 per cent.

Analysis of the Torsion Test.—The curve selected for analysis was that recommended by the authors, namely, the mean of the almost coincident curves B and C in Figs 13 and 14 of their paper. This gives the shear stress as a function of the tangent of the angle of shear, ϕ, at the outer surface of the specimen. The representative shear strain is not, however, tan ϕ but, for plane strain, γ_{13}, where

$$\gamma_{13} = \eta_1 - \eta_3 = 2\,\eta_1 = ln\,\frac{1 + \tan\frac{\phi}{2}}{1 - \tan\frac{\phi}{2}} \quad (18)$$

The stress-strain curve for analysis was obtained by doubling the shear stress and halving the shear strain as so defined, and was found to extend over two regimes of strain hardening, for which the constants are included in Table IV. The second regime is of little interest in the present context, for it is not entered until after the maxima of the pressure-dilation curves are passed.

The bulging pressure curves calculated from the first regime constants are shown on the right of Fig. 5. That based on the fully-integrated function agrees well with the experimental values. The simplified function is equally satisfactory up to initial size ratios of about 2·5, whereafter it gives bulging pressures which are about 2 per cent too high.

The fully-integrated dilation curve for the thickest cylinder was computed from the first regime constants of the torsion test, and is shown as a broken line in Fig. 4. Agreement with the experimental data is excellent, except at the extreme end where the second regime is entered. To introduce the second regime into the calculations would necessitate dividing the cylinder wall into two parts at the annular fibre upon which the strain is equal to the transition strain, and integrating each part separately. This complication is, however, of academic interest rather than practical utility, and has not been examined in detail.

* No experimental points were given by Crossland and Bones on the curve for $K_0 = 1{\cdot}581$. The open circles on the corresponding curve in Fig. 4 are readings taken from their original graph.

Experiments on Copper Tubes.—Through the courtesy of the British Oxygen Company, the results of pressure-dilation experiments on two annealed phosphorus-deoxidised copper tubes of distinctly different mechanical properties were made available. These were analysed by using the simplified function inversely in the manner already described. The stress-strain and pressure-dilation curves are shown in Fig. 6, and the strain hardening constants derived from the former are included in Table IV. The pressure-dilation curves calculated from these constants fit the experimental data excellently (Fig. 6), and the calculated maxima agree with the observed bulging pressures to within 0·08 ton per sq. in.

CRITERION OF YIELD

The strain-hardening constants which head Table IV, and which were determined by direct analysis of the dilation and torsion tests, are those applicable to plane strain, namely αS_0, αS_∞ and $\beta \eta_c$. According to the maximum shear (Guest-Tresca) criterion of yield $\alpha = 1$ and $\beta = \frac{1}{4}$, while for the octahedral shear (Maxwell-von Mises-Hencky) criterion $\alpha = \frac{2}{\sqrt{3}}$ and $\beta = \frac{\sqrt{3}}{2}$. The constants were modulated to those for simple tension by eliminating these factors for each criterion, and the ordinary tensile strengths were calculated in the normal manner[3]. They are compared with the experimental values in Table IV, and in each case the maximum shear criterion gives distinctly the better agreement. The evidence, though meagre, suggests strongly that deformation in both dilation and torsion takes place mainly upon the planes of maximum shear rather than upon the octahedral planes.

This is, in fact, an acceptable conclusion, for it is reasonable to expect that yield will commence at the earliest opportunity, that is to say, as soon as the greatest individual shear stress reaches a critical value. The octahedral shear criterion envisages that yield will be delayed until a *lower* shear stress, namely that on the octahedral plane, builds up to the required critical value, and it is difficult to understand why such delay should, in practice, occur.

CONCLUSIONS

1. It has been demonstrated that the exponential strain-hardening function can be successfully applied to the dilation of metallic cylinders under internal pressure.

2. Full integration across the cylinder wall gives good precision, but a simplified approach based on the change of thickness of the wall as a whole is sufficient for most practical purposes.

3. Methods are advanced for calculating the bulging pressure (incipient failure) of cylinders from the strain-hardening properties of the material. The bulging pressure is not directly related to the ordinary tensile strength.

4. The limited experimental evidence which has been analysed suggests that the maximum-shear criterion of yield is preferable to the octahedral-shear criterion, both for the dilation of cylinders under internal pressure and for the torsion of bars.

TABLE IV.—*Analysis of Stress-Strain Curves for Steel and Copper Derived from Dilation and Torsion Experiments*

Stresses in tons per sq. in. Strains in logarithmic units.

Material		Steel			Copper A	Copper B
Type of experiment		Dilation	Torsion		Dilation	Dilation
Regime of strain hardening		1st	1st	2nd	1st	1st
Constants for plane strain, by direct analysis of the experimental curves.						
Threshold stress	αS_0	16	16·0	32·4	4·4	5·5
Asymptotic stress	αS_∞	42·5	45·6	53·4	23·4	20·8
Characteristic strain	$\beta\eta_c$	0·05	0·059	0·205	0·107	0·123
Modulation to simple tension by maximum shear criterion.						
Threshold stress	S_0	16	16·0	32·4	4·4	5·5
Asymptotic stress	S_∞	42·5	45·6	53·4	23·4	20·8
Characteristic strain	η_c	0·067	0·079	0·273	0·143	0·164
Critical stress	S_m	39·9	42·8		20·45	17·9
Critical strain	η_m	0·188	0·187		0·266	0·273
Tensile strength	T_m	33·1	35·6		15·7	13·7
Modulation to simple tension by octahedral shear criterion.						
Threshold stress	S_0	13·9	13·9	28·1	3·8	4·77
Asymptotic stress	S_∞	36·8	39·6	46·2	20·3	18·05
Characteristic strain	η_c	0·058	0·068	0·237	0·124	0·142
Critical stress	S_m	34·8	37·1		18·1	15·8
Critical strain	η_m	0·141	0·159		0·250	0·254
Tensile strength	T_m	30·2	31·7		14·1	12·3
Experimental tensile tests (average values).						
Initial yield point			16·6		—	—
Tensile strength			33·1		15·5	13·3

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Continuing **Research and Development**

MOTION OF A BUOYANT BODY

By R. A. Collacott, Ph.D., B.Sc.(Eng.), A.M.I.Mech.E.

Department of Civil and Mechanical Engineering, Queen Mary College, London.

The retardation of a buoyant body when dropped into a liquid generally follows well-established fundamental laws. Recent photographic research into the behaviour of a glass pellet when dropped from a fixed height into a long transparent Pyrex tube containing water allowed the motion to be photographed by means of a 16 mm cine-camera. The photographs were analysed frame-by-frame and a full record obtained of the motion.

The displacement-time curves (Figs. 1 and 2) show three stages of the motion of the pellet; individual curves being plotted for several repeat-tests using pellets of three different weights, the heaviest being only just buoyant. The three stages were:

1. Free fall under the action of gravity. In most cases this was fairly stable but one or two records showed a tendency for the pellet to fall lopsided. 2. Retardation. The distance which the pellet penetrated the water was a function of the energy dissipation and since the initial height above the water was the same in all cases the amount of available energy varied directly with the weight of the pellet. The energy was dissipated (*a*) by the collapse of a cavity behind the pellet as it first entered the water, (*b*) by normal skin friction as the velocity of the pellet changed. 3. Flotation. The pellet appeared to rise to the surface at an almost constant velocity.

The graph showing the free fall and retardation stages, drawn to a larger scale in Fig. 3 for tests 4, 5 and 6, showed where the points of inflection occurred when the pellet entered the water and the speed changed from gravitational acceleration to buoyant retardation. The entry speeds for tests 4 and 5, as taken from the slope of the graph, were both 14·95 ft per second, corresponding to a height of release of 3·475 ft. For test 6 the entry velocity was 15·05 ft per second, corresponding to a height of release of 3·530 ft. These two slight differences in height of release are regarded as accounting for the difference in the displacement/time curves for the various tests, and indicate the sensitivity of this photographic method of recording the motion of a buoyant body under the test conditions.

The depth of penetration is given by the equation:—

Energy on entry = energy lost at entry + energy lost in skin friction + work done against buoyancy force.

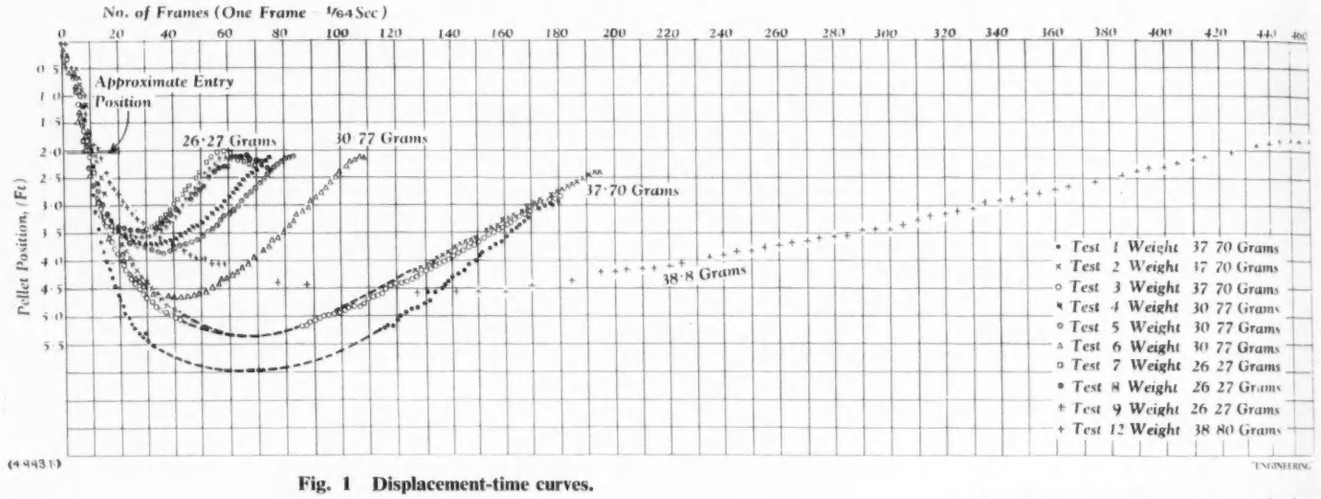
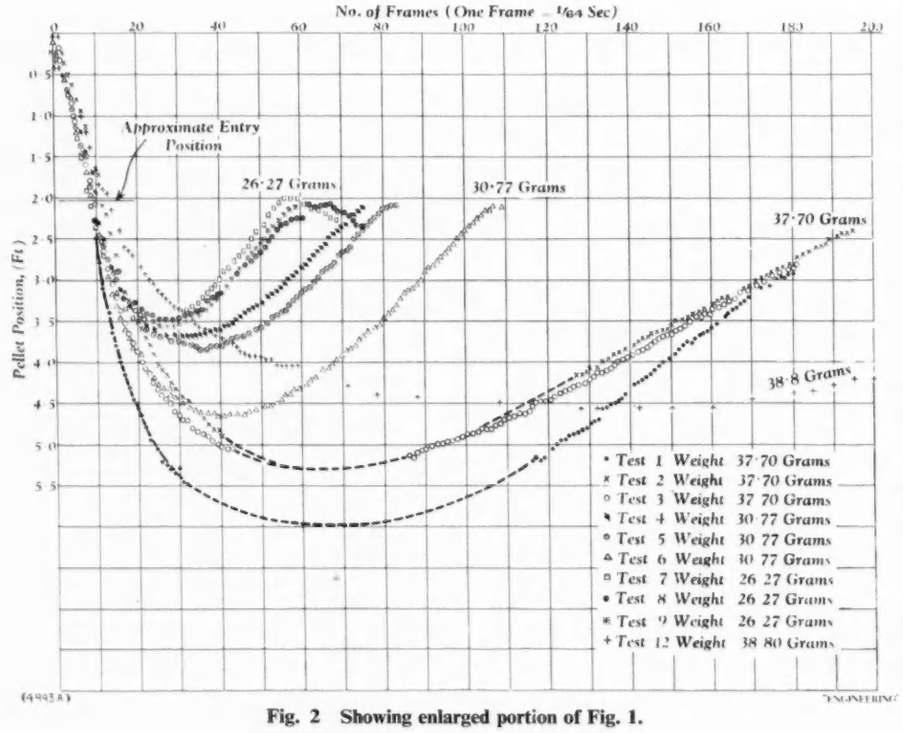

No. of Frames (One Frame = 1/64 Sec)
Approximate Entry Position
26·27 Grams
30·77 Grams
37·70 Grams
38·8 Grams
Pellet Position, (Ft)
• Test 1 Weight 37 70 Grams
× Test 2 Weight 37 70 Grams
○ Test 3 Weight 37 70 Grams
Test 4 Weight 30 77 Grams
Test 5 Weight 30 77 Grams
Test 6 Weight 30 77 Grams
Test 7 Weight 26 27 Grams
Test 8 Weight 26 27 Grams
Test 9 Weight 26 27 Grams
+ Test 12 Weight 38 80 Grams

Fig. 1 Displacement-time curves.


No. of Frames (One Frame = 1/64 Sec)
Approximate Entry Position
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○ Test 3 Weight 37 70 Grams
Test 4 Weight 30·77 Grams
Test 5 Weight 30 77 Grams
Test 6 Weight 30 77 Grams
Test 7 Weight 26 27 Grams
Test 8 Weight 26 27 Grams
Test 9 Weight 26 27 Grams
+ Test 12 Weight 38 80 Grams

Fig. 2 Showing enlarged portion of Fig. 1.

The energy at entry is the kinetic energy of the mass. The energy lost at entry is a complex function of the pellet shape and influence of the sides of the container on water displacement, the breakdown of cavities behind the pellet, and so on. The energy lost in skin friction may be regarded as proportional to pellet velocity squared. The buoyancy force is the difference between the weight of water displaced and the weight of the pellet; the volume of the pellet was found to be 39·5 cc., hence the weight of water it displaced was taken as 39·5 grams.

When measurements were made of the penetration and plotted against the kinetic energy at entry it was found that there was a certain amount of scatter in the experimental results, and that the penetration was not directly proportional to the kinetic energy at entry; a fact which would be expected if allowance were made for the effect of skin friction and of cavities.

The velocity of return or flotation was reasonably constant for each test and showed clearly that a form of terminal conditions were reached with the buoyancy forces in each case, equal to the resistance to motion and thus proportional to the velocity squared.

It was observed that in all cases a cavity was formed behind the pellet and that a large amount of air followed the pellet for some distance below the surface, subsequently forming a trail of bubbles which rose to the surface. A typical photograph of this cavity is shown in Fig. 4. This was taken with a special micro-flash arrangement to obtain a better definition than

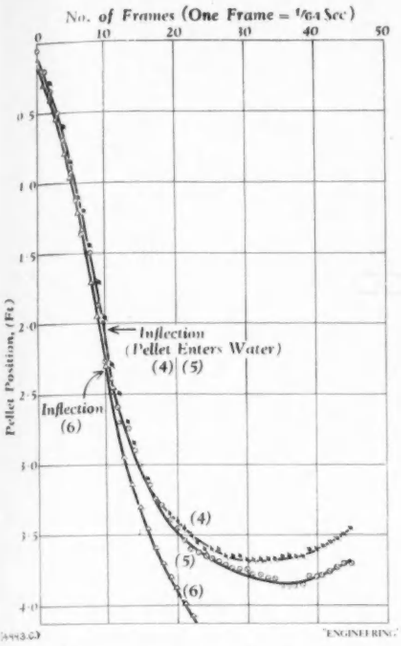


Fig. 3 Drawn to a larger scale are the free fall and retardation stages for tests 4, 5 and 6, showing where the points of inflection occurred.

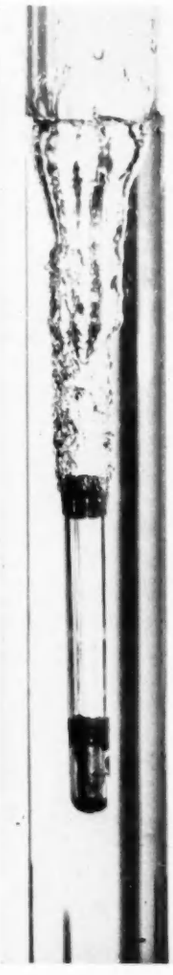


Fig. 4 (right) A typical photograph of the cavity formed behind the pellet taken with a special microflash arrangement.

that obtained from enlargements of the 16 mm film.

This report indicates that a fairly elementary hydrodynamic problem can be further and satisfactorily investigated by photographic means to provide both visual and quantitative results, if adequate facilities are available for analysing the numerous records. Certain basic data have been gained which might be applied to further full-scale investigations to determine the influence of form and irregular under-water motion on the behaviour of a moving submerged body.

Photocopies of the full paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, *36 Bedford Street, London, W.C.2, price 25s., post free. Orders should be accompanied by a remittance.*

Metals and Materials

METALLURGY AS A CAREER

The annual luncheon of the Institution of Metallurgists took place on 20 May at the Park Lane Hotel, Piccadilly, London, with the newly appointed President, Mr. W. E. Ballard, in the chair.

Proposing the toast of the Institution Sir Gilbert Flemming, K.C.B., Permanent Secretary, Ministry of Education, referred to the happy and close collaboration between his Ministry and the Institution on educational matters. He thought the Institution could do much to make metallurgy attractive as a career to the increasing number of students staying on in the sixth forms after the age of seventeen. He suggested that the appeal should be made sufficiently wide to attract girls as well as boys. For those who left school earlier (only 15 per cent stayed on after the age of seventeen) there should be opportunities to take technological courses and he was very appreciative of the efforts of the Institution in this direction. There were already three courses in metallurgy recognised for the Diploma in Technology. Mr. A. G. Stewart, chairman and general managing director, Stewarts and Lloyds Limited, spoke of the relation between the Institution and industry; it was for the former to build up the nation's resources of trained metallurgists but it was the latter who would provide the opportunities.

For his presidential address, which was delivered to the annual general meeting, following the luncheon, Mr. Ballard referred to the history, work and aims of the Institution. The first annual general meeting, he said, had been held on the 28 November, 1945, when Dr. Harold Moore became the first President and Mr. Headlam-Morley the first Secretary. Members owed a debt to these gentlemen and many others, who, having gained high academic honours for themselves gave freely of their time to obtain for younger men and women advantages from which they themselves had not benefited. The Institution had maintained a high standard of qualification, and to be a member was a symbol that one was held in high esteem by others in his profession. Mr. Ballard considered that the young graduate should regard it as essential to become a member of the Institution, since membership signified experience as well as a considerable measure of academic success.

The metallurgist, continued Mr. Ballard, did not always appear to take his rightful place in industrial management. Young men entering the profession, while highly trained in scientific knowledge, too often appeared to lack the ability to make decisions and take responsibility. Understanding of mankind was essential in all forms of management and every opportunity should be given to young men coming into industry to study his fellow workers, to travel and meet other metallurgists and customers. Human relations of this type could not be learned from books or by university instruction. The assertion that scientists or technologists were not good business men was erroneous and should not be tolerated.

The Institution, concluded Mr. Ballard, had achieved much in a short space of time but it had still a long way to go. More could be done in the interests of its members, and it could only be considered as having been entirely successful when each practising metallurgist was a member and when every metallurgist was qualified.

OIL ADDITIVES

Two new products have been developed by the Amber Chemical Company Limited, 11A, Albemarle Street, London, W.1. These are Amber SSR 511 which, when added in small amounts to fuel oils will, it is claimed, reduce to a harmless level the formation of sludge during normal storage periods. The treatment is said to be particularly effective in improving the stability of fuel oils made up of straight-run distillates and components produced in catalytic cracking units.

Amber SSR 511 should be added to the fuel tank, via the filling line, before bunkering the oil. It acts to dissolve existing sludge in the tank and fuel system, retard the formation of further sludge, and generally improve atomisation and combustion of the fuel. Cost of the treatment approximates 0·06*d.* per gallon of oil consumed.

The second is Amber SSR 513, designed for the treatment of diesel fuels. The action of this product is to soften and break up the binders in carbon and lower its ignition point; thus preventing the formation of the hard deposits which commonly accumulate in piston ring grooves.

The use of this treatment for diesel fuels may be extended to boiler oil, which is being increasingly used by the shipping lines operating low speed diesel engines having a high or even load, as is usually the case in the main engines aboard ships. The cost of treatment approximates 0·13*d.* per gallon of diesel oil consumed.

"DRY" BEARING MATERIAL

Three new "dry" bearing materials are now being produced by the Glacier Metal Company, Limited, Alperton, Wembley, Middlesex. They are the DU, comprising thin steel strip with a porous bronze coating impregnated with a mixture of a fluoro-carbo plastics (P.T.F.E.) and lead. This new material provides three times the load/speed carrying capacity of the company's original DP material which it now supersedes. Stock ranges of bushes, thrust washers and flat strip are available for manufacturers wishing to conduct their own experiments.

The second is the DQ—a fluoro-carbon strengthened with special fillers and supplied in bars and tubes. Non-standards or irregularly shaped dry bearings can be simply machined from this material, which can be supplied from stock in standard diameters; and the third is DM—a process for applying an adherent layer about 0·0015 in to 0·0025 in thick of a combination of fluoro-carbon and molybdenum disulphide to the bearing surfaces of customers' components.

HIGH IMPACT PLASTICS SHEET

Fromo Plas N is a high tensile, high impact strength plastics sheeting introduced by Wallington Wester and Company Limited, Frome, Somerset. A rigid thermoplastic, it will withstand repeated hammer blows with little indentation and has an Izod strength of 6·5 to 7·5 ft-lb, using a $\frac{1}{2}$ in notched bar specimen. It is non-inflammable and soluble only in ketones and esters. The dielectric properties are excellent.

At present the sheet is available in various colours (glossy one side, matt the other) and in standard sizes ranging from 4 ft by 3 ft to 8 ft by 3 ft. Thicknesses are from 0·02 in to $\frac{1}{16}$ in, or up to 1 in in smaller size panels. Continuous rolls 0·01 in thick can also be obtained.

Book Reviews

MARITIME CONSTRUCTION

Dock and Harbour Engineering. Volume 1: The Design of Docks. By H. F. CORNICK *Charles Griffin and Company Limited, 42 Drury Lane, London, W.C.2.* (105*s.*)

The engineer engaged in the construction and maintenance of docks and harbours is faced with a very wide range of problems. In the civil engineering field alone he must deal with quays, locks, dry docks, jetties, roads, railways, bridges, tunnels and a wide variety of buildings. In the mechanical and electrical fields there are cranes, pumps, mechanical handling appliances, mobile plant, floating plant and the generation and distribution of electrical and hydraulic power and this catalogue is by no means comprehensive. To cope with this wide range the maritime engineer must not only have a sound basic training in engineering science but he must also constantly strive to widen his experience both at first hand and also through the medium of technical literature. " Learning by doing " is the optimum approach, but one cannot have done everything and the careful study of accounts of how problems have been overcome by others is of the greatest value.

However, with so wide a variety of activities the maritime engineer has an overwhelming task in keeping abreast of the technical literature from all over the world which is germane to his subject. This is firstly a problem of availability of time and secondly of selection and it is a problem which grows increasingly oppressive. How welcome therefore is Mr. H. F. Cornick's action in joining the very small group of engineer-authors who have attempted the formidable task of writing a treatise on maritime engineering. Indeed among British engineers only two others have attempted the task: Dr. Brysson Cunningham and Mr. F. M. Du-Plat-Taylor. (It is interesting to note that, like Mr. Cornick, both were at one time or another during their notable careers with the Port of London Authority).

Dr. Cunningham's two books *Dock Engineering* and *Harbour Engineering* were last issued in 1922 and 1928 respectively. Mr. Cornick has in effect revised and refined the material in these two works and used it as a basis for a very much larger and up-to-date treatise in four volumes, of which the first to be published runs to 332 pages in demy-quarto. If the remaining volumes are comparable in size this treatise will indeed be a work of encyclopaedic range.

As befits a treatise written by an engineer much thought has obviously been given to the design of the book. The author commences with a historical survey of the development of dock construction and administration, then deals in a general way with their design and layout and goes on to devote individual chapters to specific subjects—dock walls, entrance locks, dry and floating docks, slipways, lock gates and caissons. Each chapter also reflects this treatment, introductory paragraphs being a general survey of the subject with historical notes followed by a most comprehensive and valuable series of examples from the author's own wide experience and also from a truly remarkable acquaintance with world-wide technical literature.

It is in this wide ranging sweep of examples that the work has its greatest merit, and in providing these examples Mr. Cornick has appreciated that to the engineer one carefully selected drawing clearly reproduced is worth many pages of descriptive text. His chapter on dock and wharf walls alone contains 98 illustrations, in general each one referring to a different subject, and each illustration has a brief descriptive paragraph. In the whole volume there are 302 illustrations. This excellent feature is enhanced by a comprehensive bibliography at the end of each chapter and by a carefully composed index at the end of the volume. A small but valuable improvement would result if, with each illustration, there was given the date of its construction, for in engineering, as in all branches of science, a feeling for the historical development of the subject makes for deeper understanding.

Considering the breadth of the subject with which the book deals it would indeed be surprising if criticism could not be levelled against it in one way or another but this book is remarkably free from faults. One that could be mentioned is that in considering the design of dock and wharf walls, to which a chapter is devoted, it has not been found possible to treat of the basic structural design in the same chapter. This is to be dealt with in volume IV where chapters are devoted to soil mechanics and calculations for the stability of this type of structure. As opposed to this the chapter on lock gates includes a section on structural design.

In the preparation of a work of this magnitude considerable time must elapse between the completion of the manuscript and the eventual appearance of the book and it is to be expected that the very latest developments in the subject could not be discussed. Thus the book does not contain descriptions of some of the very interesting modern developments in dry dock construction (e.g. the use of prefabricated buttresses in wall construction, and floors tied down by high tensile steel cables to buried anchorages, or other means) and the development of the " box " type flap gate with side bearings, the continuous bottom trunnion being obviated.

In a preface, Mr. Cornick writes that the treatise was written primarily for students. In so far as engineers remain students all their lives (or should do so) the book is well directed but one cannot help feeling that a student proper would be overwhelmed and certainly greatly discouraged by the mass of information presented to him. The book, one would suggest, is somewhat too weighty to serve as a textbook for the completely inexperienced. Its future will surely be secure, as Mr. W. P. Shepherd-Barron states in his foreword, as " an essential work of reference for all concerned with the design, construction and operation of docks and harbours." It is a concise and comprehensive distillation of the author's own life's experience and reading in the field of maritime engineering presented in lucid and readable style and set out in a fashion that will be appreciated by his engineering readers.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Plastic Tools. SHELL CHEMICAL COMPANY LIMITED, 15/17 Great Marlborough Street, London, W.1. Illustrated technical bulletin with details of Epikote resin tools of both the cast and the laminated type. The bulletin deals with both working tools such as those used for producing metal pressings, and auxiliary tools such as jigs, fixtures and foundry patterns.

Abrasive Products. MERCIA ENTERPRISES LTD., Allesley Old Road, Coventry. Rubberised abrasive wheels, points, sticks, blocks and cones, made by the Cratex Manufacturing Co., Burlingame, California, U.S.A. Illustrated leaflets giving details of these products, for which Mercia Enterprises are the sole British distributors.

Machine Tools. SOAG MACHINE TOOLS LTD., Juxon Street, London, S.E.11. Stock list of reconditioned machine tools. Boring, milling, turning, grinding, drilling, planing, slotting, sawing and keyseating are all represented, as well as some other operations such as pressworking and cold heading.

Welding Manipulators. COURTBURN POSITIONERS LTD., Kempston Hardwick, Bedford. Low cost manually operated rotators for cylindrical vessels from 1 ft to 7 ft 6 in diameter, and bench mounted, power driven, variable speed rotators for loads up to 1 cwt. Illustrated leaflet.

On the Shelf

By Frank H. Smith

Macmillan (London not New York) have brought out a neat little booklet entitled " Macmillan Books for June to September 1958." A copy is obtainable from St. Martin's Street, W.C.2.

I have had a circular, from International Communications Inc., P.O. Box 122, Grand Central Station, New York 17, U.S.A., starting: " A select group of leading international editors will soon receive from the United States the very first issue of the *U.S. Industrial Digest*." It is to be hoped that leading international editors will be impressed by this " very first issue."

Our old friends the Engineering Institute of Canada must have a whacking postage bill for April. They have put out their " Report of Council " which is a 45-page booklet and at the same time a special " Canada 1957 " number of the *Engineering Journal* that is half an inch thick and weighs " half a ton." This review is divided up into sections with such titles as " Mineral Resources," " Power," " Communication and Transport " and so on. A quite valuable survey of the already up and still coming Dominion.

Twice a year, American Aviation Publications, 1001 Vermont Avenue, N.W. Washington 5, U.S.A., produce a *World Aviation Directory*. The spring/summer edition is now out (10 dol).

Librarians and other types concerned with the keeping of records of periodicals received are having a pretty harassing time of it these days. Even the most conservative publishers seem to be intent on changing their forms, formats, titles, covers and anything else that has been taken for granted for years past. These harassees are advised to take a good look at the editorial in *Mechanical Engineering*, the Journal of the American Society of Mechanical Engineers, for May, because there is going to be a good old muckabout with the *Transactions* of the ASME from January, 1959. Incidentally, the subsequent two pages (after the Editorial) form an excellent commentary on the position of the United States *vis-à-vis* the U.S.S.R. If I comment on it I may find myself accused of anti-Statery and pro-Sovietry. And while we are on this subject, if any of my readers are interested in the ethics of atomic warfare and how it affects the engineer he may care to get in touch with Howard G. Kurtz Jr. of Hardy Associates Inc., 570 Lexington Avenue, New York 22, U.S.A. This gentleman has a " thing " about the business and is prepared to distribute a reprint entitled " An Engineer vs. War " from the *American Engineer*.

For some unknown reason, advertisers in the " Sits Vac." columns have a predilection for " technical authors." Rarely do they require a technical writer which, to my mind, would be a better description of the man they require. This preference appears to have spread to the City and Guilds of London Institute, Gresham College, Basinghall Street, London, E.C.2, which has just published, at 9*d.*, pamphlet 229—*Technical Authorship*. It may be remembered that some prominence was given a short while ago to the Institute's intention to set a seal of proficiency on this profession and the pamphlet outlines the training requirements (or background in the case of a practising writer) and gives the syllabuses (Oxford's first choice is syllabi) of the intermediate and of the final examinations. The goal is a certificate in the intermediate or final of first or second class. A silver and a bronze medal can also be won. The intermediate examination will be first offered in 1960 and the final in 1961. He who is contemplating becoming a certified [*sic*] technical author by 1961 will be well advised to get the pamphlet and make sure he knows enough of his own language to make a start.

Penguins have brought out *The Penguin Guide to London*, price 6*s.* An odd piece of information for this column but what is one more oddity among so many?

Construction

NEW CHEMICAL ENGINEERING BUILDING

at the Manchester College of Science and Technology

The conversion of a cotton mill into a chemical engineering building may be regarded as symbolic of general industrial trends in this country. That it should occur in Manchester is perhaps also a good omen for the future industrial prosperity of this country, for if we must prosper we must look ahead to the future and not rest on past achievements. The converted building provides new chemical engineering laboratories for the Manchester College of Science and Technology.

The new facilities are a converted cotton mill in Jackson Street, Manchester, and the whole project is an outstanding example of economic planning. From start to finish the project took fifteen months to complete, and a teaching area of approximately 120,000 sq. ft comprising chemical engineering laboratories, drawing offices and lecture theatres has been provided at a cost of approximately £488,000. This cost includes the purchase price of the building, laboratory furnishings, office furnishings and furnishings for the pilot plant buildings, but does not include the equipment required for teaching.

The building work was planned in two phases. The first phase, commenced in October 1956, was the conversion of the basement, ground floor, and first and second floors for the use of the chemical engineering department and that portion of the mechanical engineering school dealing with the strength of materials. This work was completed by October 1957 when the first teaching in the new premises began. Meanwhile it had been found possible to proceed with some of the constructional work for phase two which provided for the conversion of the upper floors of the building into laboratories for the industrial biochemistry and textile chemistry departments, and large drawing offices for the teaching of engineering drawing to all the engineering departments of the College. Phase two of the conversion scheme was completed in January 1958, some six months ahead of schedule.

The main building, including basement, ground floor and six floors, totals about 120,000 sq. ft in area and is separated by the main staircase and lift shafts from a five-storey block containing floor area of about 32,000 sq. ft. In the basement of the main building is the strength of materials and fatigue testing laboratories of the mechanical engineering department, and at the northern end of the basement is an area forming the lower portion of the chemical engineering laboratory which extends from the basement through the ground floor to provide space and access to tall units such as extraction and distillation columns, evaporators and similar equipment.

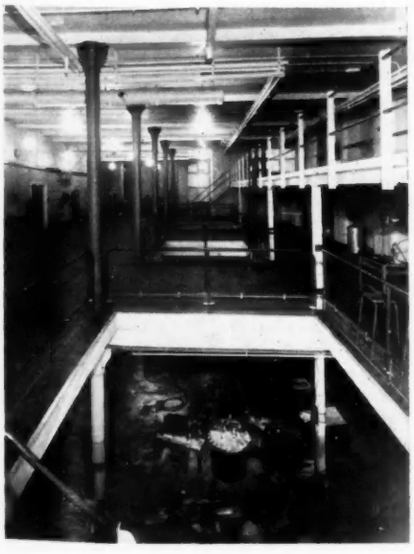
On the ground floor is the main lecture room capable of seating 130 students, sound proofed and fitted with cinema and sound projection equipment; other teaching laboratories on this floor are located around a central hall in which facilities for student refreshment are provided. The first floor contains the drawing office which provides adequate working space for 60 students, together with research laboratories, conference room, library, lecture rooms and office facilities for the chemical engineering staff.

Additional facilities for the metallurgical department are provided on the second floor where there are laboratories for metallurgical analysis, for general metallurgy and for metallography. Also on this floor are facilities for teaching fuel technology and research laboratories. The third floor is devoted to textile chemistry with laboratories for the study of the chemistry of textiles, the physical properties of textile materials, microscopic analysis, the study of elastomers and plastics, and a number of smaller research laboratories. The industrial biochemistry department, with two large teaching laboratories and several research laboratories with inoculation media, autoclave, constant temperature, and cold rooms, is situated on the fourth floor. The large drawing office on the fifth floor has provision for 300 students at a time, although it is divided into rooms by partitions which split the classes into smaller groups.

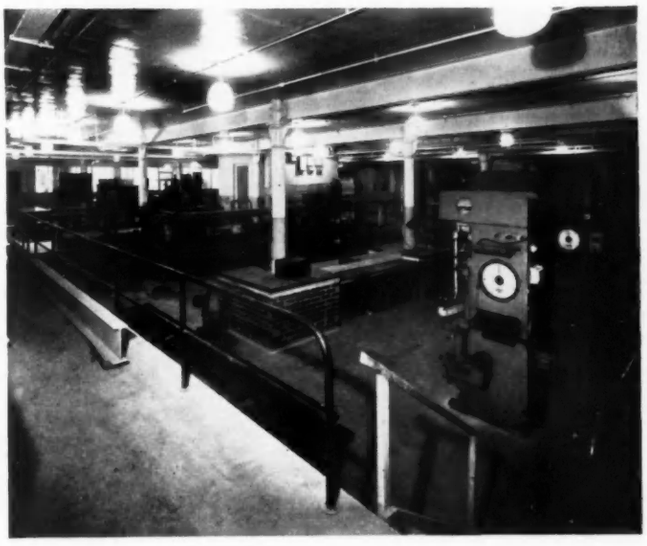
The provision of services to so large a floor area, particularly that of ventilation, has been accomplished by four 10 ft square ducts which extend from the basement to the top floor. Through these ducts the ventilation piping is taken to the fans on the sixth floor and the electrical, steam, gas and water supplies are brought to the various laboratories. With the exception of the ground floor, the headroom on any floor was insufficient to enable false ceilings to be constructed behind which to hide the various services to the laboratories. Therefore all services to the benches are brought along the ceilings of the rooms beneath to feed the service boxes of the laboratories above. Since several of the laboratories are to be used for both undergraduate teaching and research, the provisional layout was made on the basis of the maximum number of benches which could be included in any given laboratory area, but not all these services are employed; when not in use they are covered with a plate which fits into the floor of the laboratory.

Apart from the main chemical engineering building, there has been erected between the main building and the River Medlock two large

From Cotton Mill to College Laboratory.



(Left) Main Chemical Engineering Laboratory.



(Right) Strength of Materials Laboratory.

Production

MAKING CARTON BOARD

Fig. 1 (left) Waste paper and wood pulp from the raw material store at the far end of the building are used to make board 110 in wide for folded cartons at the rate of 600 ft per minute.

Fig. 2 (right) At the "wet" end of the machine the stock is fed to belts to give the desired thickness.

THE first complete board mill to be built in Britain for 25 years began production at Thatcham (Berkshire) earlier this year. It makes the third mill that the Colthrop Board and Paper Mills Limited (a member of the Reed Group) have at this site, although the earlier ones are on the opposite side of the railway. When in full production the new mill will produce 600 ft per minute of board 110 in wide for carton manufacture. The project has been completed in almost exactly three and a half years from placing the order for the board machine. For the mill the architects were Elliott, Cox and Partners, and the main contractors Taylor Woodrow Construction Limited, while for the associated power station the consultants were J. D. Crozier and Partners Limited and the contractors Holst and Company Limited.

Four main types of board are to be produced in the mill: white-lined manilla; white-lined chip; cream-lined chip; and kraft-lined chip. All are used for making folding cartons such as cigarette packets, cereal packets, cartons for cakes, and the like. The board is made up of four types of material built up to give eight layers. The types are known as the liner, the under-liner, the middles and the backs. All but the liner are made from waste paper (and therefore the raw material does not have to be imported), rough waste for the middles which have little strength but make up the thickness, and selected waste for the backs. Wood pulp is used for the liner.

The raw materials pass first to the four Black-Clawson hydra-pulpers of which the two dealing with the waste are fitted with raggers and junk removers for extracting the string, paper-clips, pins, etc. Stock cleaning follows, the middles passing through a battery of Vickery Jumbo Dirtecs to Black-Clawson Classifiers. Then comes stock thickening in Watford machines. The underliner and backs stocks follow a similar cycle. The liner stock is treated in a hydrafiner with a duo-cycling system. Remote controls allow the cycle to be preset by the operator.

Eleven reinforced-concrete tile-lined stock chests hold the stock before it is finally refined in seven Walmsley conical refiners, which are on a raised platform above the first floor level. Their purpose is to ensure that the stock is in a very finely divided condition before it is laid in

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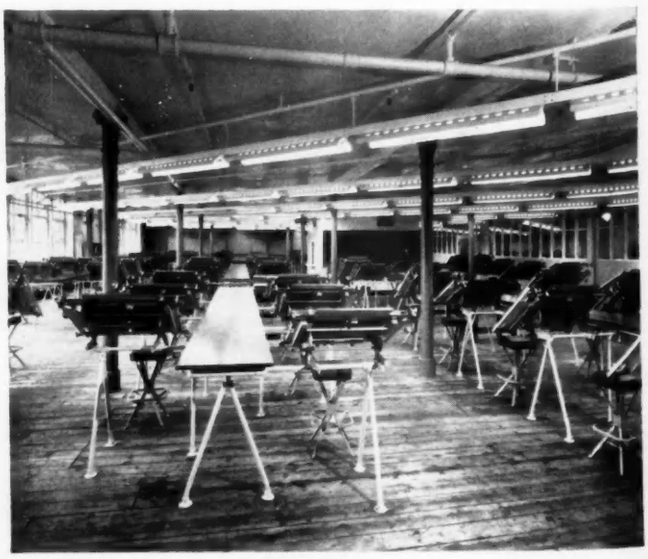
Continuing Construction

prefabricated steel buildings to house pilot plants. The building of these pilot plants will form part of the training of chemical engineering students. It is not expected that these buildings will be fully equipped before the end of 1960, but students are already designing the first pilot plant—a tar washing unit—and it is hoped to commence the erection of this unit in the summer of 1958.

Chemical engineering has an important contribution to make to our industrial prosperity. The report "Scientific and Engineering Manpower in Great Britain" (H.M. Stationery Office, 1956) estimated that by 1959, 2,200 chemical engineers—an increase of 47 per cent as compared with 1956—would be required. The expansion of the chemical engineering department of the Manchester College of Science and Technology is therefore timely and is an important contribution to the provision of teaching facilities to provide the increased number of qualified chemical engineers.

Contracting firms in connection with this conversion scheme were: Harry S. Fairhurst and Son, Manchester 2 (architects, surveyors); R. R. Jennings and Partners, Manchester 3 (consulting engineers); Ernest R. Babbs and Sons, Manchester 2 (quantity surveyors); J. Jarvis and Sons, Sale (general contractors); G. N. Haden and Sons, Manchester 1. (mechanical services); A. E. Sudlow and Company, Manchester 1 (electrical services).

On Monday, 19 May, Sir Alexander Fleck, K.B.E., chairman of I.C.I., officially opened the new Chemical Engineering Building. Councillor M. P. Pariser, Chairman of the College Council, presided at the opening ceremony and was supported by the Lord Mayor, Ald. Leslie Lever, J.P., M.P.; Professor W. Mansfield Cooper, Vice-Chancellor of the University of Manchester; Dr. B. V. Bowden, Principal of the College; and Professor Frank Morton, head of the department of chemical engineering, fuel technology and metallurgy. Sir Hugh Beaver, K.B.E., President of the Federation of British Industries and President of the Institution of Chemical Engineers, thanked Sir Alexander on behalf of the College and the chemical engineering industry, and Mr. H. Fairhurst, the architect responsible for the conversion scheme, presented him with a memento of the occasion.



Engineering Drawing Office.

Fig. 3 (below) The formed board is dried in its passage over 130 rollers. Beyond are the calenders, reel-up and slitting machines.

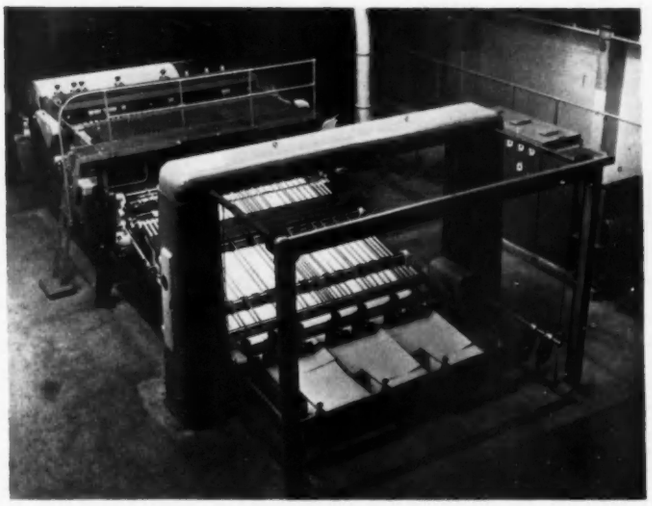


Fig. 4 (above) Finished board can be supplied in reels, or as shown here, in sheets cut to the required size for particular cartons.

the board machine. Alum and size are added at various points in the preparation cycle as required for the grade of board being produced. Since there is a lot of hot liquor in the preparation house special heating and ventilating plant, supplied by Carrier-Ross, has been installed.

The board machine is installed in a house 435 ft long and 75 ft wide (including the drive annex) with a height of 62 ft. Framework, floor, and roof are of reinforced concrete construction. The board machine, constructed by Walmsleys in association with Walker Brothers, and in co-operation with the Colthrop staff, is of the basement type and yields trimmed board 110 in wide at a maximum designed speed of 600 ft per minute. The four stocks are delivered to the compartmented head box and so to the vat section, which comprises eight cylinders and vats. This section is followed by an extractor roll, a suction roll, and then five primary presses. In the main press section there are two plain presses with a suction press between them; all have granite top rolls. Long-stroke hydraulic oscillators are fitted to all mould and felt shower pipes, with short stroke units for the press roll and pre-drying cylinder doctors.

In the pre-drying section there are 26 steam-heated cylinders arranged horizontally in two tiers with a Ross Grewin vapour absorption system. The main dryer section has 130 cylinders arranged in eight vertical stacks. A steam-heated smoothing press is located between the second and third stacks. The Carrier-Ross vapour absorption heating and ventilating systems are installed above the drive annex; a high level of performance is required to prevent condensation. At the end of the line are two finishing calenders, each of seven rolls, followed by the reel-up machine, taking reels up to 76 in in diameter. Separately mounted is a Masson and Scott slitter and rewinder, driven from a Velotrol mercury-arc rectifier.

The board machine is driven by a Harland interlocked sectional electric drive having an operating range from 100 to 600 ft per minute, and a crawl speed of about 30 ft per minute. There are 25 separate driving units supplied from a 500 kW motor-generator set. Igranic switchgear is used in the greater part of the plant. The thickness of the board produced is continuously monitored by Baldwin Atomat gauges.

Reels of board are transferred from the first floor level where they are wound, by a trolley and crane to the ground floor of the finishing hall. Here a Masson Duplex supercutter and a Simplex cutter, and a Thrissel slitter and rewinder cut the sheet to size. Trimmings are returned to the broke beater and recirculated to the stock. The cut sheets are stored in this hall and are kept mainly on pallets for easy handling. Much of the cut material is supplied direct to Cropper and Company Limited (another member of the Group) whose factory is situated on the opposite side of the railway.

Electricity and steam for the various processes are supplied from a separate power station. In this are installed two International Combustion boilers each rated for 88,500 lb of steam per hour at 525 lb per sq. in and 780° F. These feed a Metropolitan-Vickers pass-out turbo-alternator rated for 7,500 kW at 11 kV, which can be paralled with the mains supply. The pass-out steam can be adjusted between 20 and 60 lb per sq. in, and is fed to the mill through a 21 in main. Water for all purposes is obtained from the Kennet and Avon canal and the effluent is returned to the same after full treatment. Coal is delivered by road and rail. The mill, which cost approximately £5 million is operated by 46 men per shift with about 70 more employed on maintenance work.

SEQUENCE CONTROLLER APPLIED TO CAPSTAN LATHE

There are many operations in industry which require a set sequence of events for their completion, and there are many devices for running through the sequence automatically. One that was shown at the recent Production Exhibition was developed by Nickols Automatics Limited, 7 Carlisle Road, London, N.W.9. It was shown in action on a Herbert 2D capstan lathe.

The actual control unit is made up of an sequence switch with the contact terminals brought out to a plug board. In the standard model there are 24 steps, each provided with four sockets. This arrangement allows, for example, for three functions and one signal to be plugged in at any moment. Some form of indicator is required on the machine, such as a limit switch, to give the signal when each operation is complete. This signal energises the sequence switch which then moves on one step, and initiates the next operation. A manual control allows the sequence to be interrupted at any stage.

The transmission from the controller to the machine can be electropneumatic, electro-hydraulic or all-electric. It is also possible to adapt the system for all-pneumatic or all-hydraulic operation if electricity is not wanted. One advantage of the system is that the timing is inherent; each step is made in the time of the machine itself and no complicated cam timing is needed. Setting up the sequence consists solely of plugging the leads into the sockets in the order in which the movements occur, and much of the tedious work is removed from the setter. Use of the control renders the machine fully automatic. If for any reason an operation is not completed, the cycle stops and extended damage to the tools is avoided.

The sequence of operations is obtained by plugging the leads into the sockets in the order in which the movements occur.

Design

STANDARD CONTROL FOR THE NATIONAL GRID

The Central Electricity Generating Board's electricity supply system, the Grid, is the largest system under unified control in the world. It consists of 260 power stations, with an aggregate capacity of 22,000 MW, and 350 main electricity distributing centres. The whole system is connected together by the Grid and is operated as a unit so that the power stations which generate most cheaply are used to the maximum extent. To achieve this co-ordination, there are for England and Wales seven Grid Control Centres—each in direct communication with power stations and main switching points in its area—and a National Control in London—in direct communication with the Grid Control Centres at Newcastle, Leeds, Manchester, Birmingham, Bristol, and the two near London. Twenty-four hours a day the organisation is checking costs of generation, planning generating programmes, and issuing instructions for generating plant in power stations to be started up or shut down. In this way, the constantly changing demand for electricity at the lowest possible overall cost, is met. To increase the efficiency of co-ordination, modern centres have been installed to take the place of the original ones, now 20 to 26 years old. Although some time must elapse before the new National Control network is completed, operational experience has been most gratifying, say the C.E.G.B, in those areas where the standardised system has been in operation for several months.

Fig. 1 (left) The walls of the Thames North Grid Control room carry the switching and feeder flow diagrams.

It is now 26 years since the Grid system was first put into operation by the Central Electricity Board. For control purposes the country was divided into seven districts, with combined Grid Control Centres (GCC's) and district headquarters in London, Bristol, Birmingham, Manchester, Leeds, Newcastle, and Glasgow respectively. The grid control areas remain substantially the same to-day.

In the early 1930's, control areas were equipped from five differing systems of general indicating, telephone, and telemetering equipment. These used rented Post Office lines from the power stations in the control area to a central trunk exchange and thence to the GCC in the suburbs. Signals were automatically transmitted from the stations to indicate the functional condition of circuit breakers and the tap positions of the on-load tap-changing transformers. Communication with the GCC and district headquarters was provided from telephones in the grid switching stations and associated power stations, which at that time were owned by power companies and town corporations. Power station control rooms also had instruction indicators which responded to any of seven instructions transmitted by the GCC control engineers.

Continuous telemetering was used in Birmingham, but elsewhere " on request " systems were employed. The telemeters indicated the active and reactive power transfers through the grid transformers and on the inter-area feeders; and also indicated power station total MW generation from transmitters hand set by the power station operators. " On request " telemetering of inter-area transfers was soon displaced by continuous telemetering systems. The first grid feeder flow diagram was commissioned in 1937 at the National Control Centre to display on a national scale the power transfers between the different control areas.

With the expansion of the grid, particularly during the war, individual installations had to be modified from time to time, and the cost and engineering effort expended emphasised the need for a readily extensible and standard system for general indications, telephones and telemetering. In 1949 it was decided to re-equip the 15-year-old grid control networks with a standard system of general indicating, telephone, and telemetering equipment which could be extended from time to time to suit changing conditions. The then British Electricity Authority and the telephone manufacturers concerned —Automatic Telephone and Electric Company Limited, General Electric Company Limited, and Standard Telephones and Cables Limited—set up a Telecommunications Technical Committee (TTC) to plan and design the " standardised system."

In view of the complex variety of stations and network conditions, the standardised system could not be a precise installation with universal application. But a rigid standardisation of many different items of equipment which could be installed in different combinations to suit the requirements of different stations was practicable. It was decided to continue using rented G.P.O. lines because they had proved to be satisfactory for 15 years, and there is no better alternative.

In the " standardised system " the stations in a grid control area are considered as being either major stations or minor stations. A major station is usually a generating station, either with or without a grid switching station, or is a large, attended grid switching station not associated with a generating station. Only the major stations are equipped to send signals to, or receive signals from, a GCC. A major station usually has a direct line to the GCC, in which case it is termed a radial station, and has also a direct line to each minor station associated with it, usually not more than three or four. A minor station is usually a small grid switching and transforming station or a bulk supply point to an Area Board. A minor station can only send signals to or receive signals from a major station. Fig. 4 shows a typical communication network.

To economise in rented circuits, the more distant major stations are connected in groups, usually of two, but up to a maximum of four stations. A group is served by a common line from the GCC to the nearest or more important station in the group and from this parent station by separate lines to each of the satellite major stations in the group. Pairs of major stations served by separate lines to the GCC are interconnected by tie lines to provide an alternative, although indirect, means of communication with the GCC. The more important radial stations may have second lines to the GCC, which are switched to take over service should the normal line fail. In everyday use, reserve lines operate as inter-PAX tie lines between the GCC and the stations. Tie lines and reserve lines are routed by the Post Office to avoid cables containing the grid control lines.

A new network is being provided for the full scale transmission of general indications, telephony, and telemetering to a new National Control Centre in London from the various GCC's and will provide communication and standby telemetering facilities between the South of Scotland Electricity Board's GCC at Glasgow and National Control. This network will also give direct communication facilities between the GCC's and connect with standby National Control Centres. The G.P.O. teleprinter network between National Control and the GCC's will be retained to reinforce the new network.

Fig. 2 (right) The Grid Control Areas in 1958.

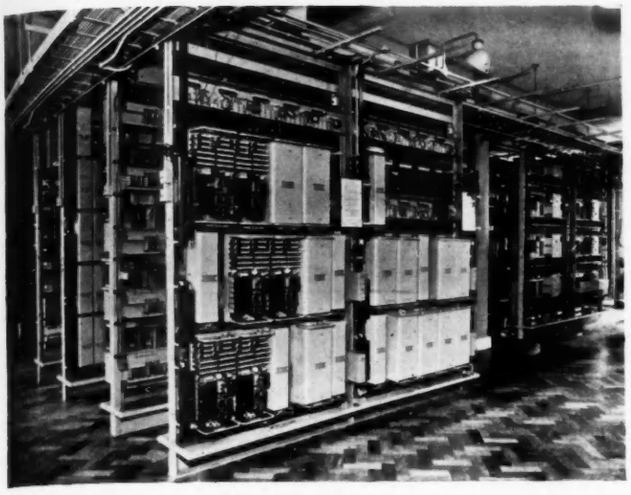


Fig. 3 The apparatus room of a Grid Control Centre houses a large portion of the standardised equipment.

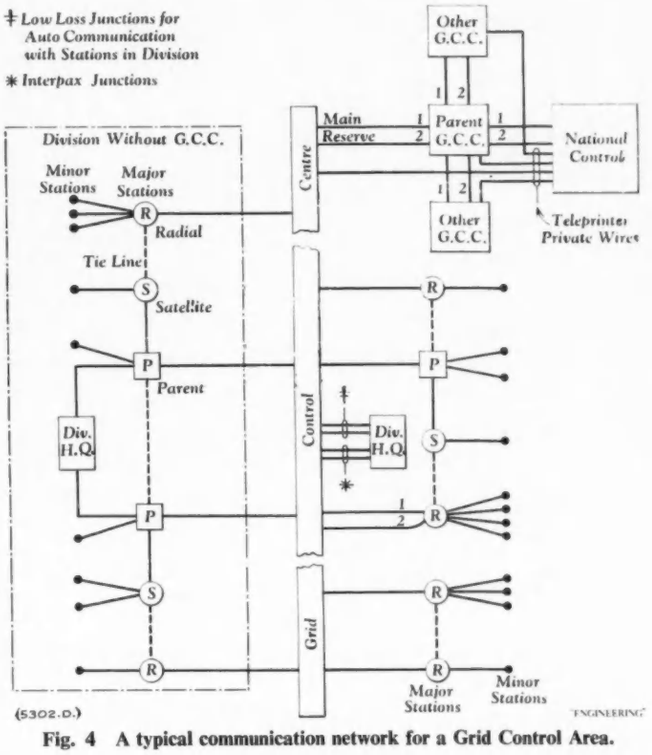


Fig. 4 A typical communication network for a Grid Control Area.

GRID CONTROL ROOMS

In each of the GCC control rooms the layout of the equipment is different, but the departure from uniformity does not affect the "standardised system."

Since they have proved satisfactory over the past 20 years, mosaic switching diagrams are used. These comprise thousands of interchangeable plastic squares which are either blank or engraved to portray various items of transmission equipment and switchgear. Their colour represents the appropriate system voltage. By replacing blanks with symbols it is a simple operation to keep the diagram in step with system development. The circuit-breaker symbol is a manually operated semaphore which flashes until corrected by the switching control engineer. For a typical control area comprising 20 generating stations and 30 grid transmission stations the average size of mosaic switching diagram is about 50 ft long by 9 ft high. It has 1,500 semaphores for breakers, isolators, and earthing switches. Usually about 500 automatic indications are provided.

Feeder flow diagrams, first used at National Control in 1937, incorporate telemeters in mimic power lines which indicate the magnitude and direction of active and reactive power flow in the various 275 kV power lines and transformers, and in the majority of the 132 kV lines. In each line a red lamp flashes when the current exceeds a preset value, while at the line ends green lamps light whenever the switchgear opens the line. A typical feeder flow diagram has about 100 telemeters and is 25 ft long by 9 ft high.

Facing the switching diagram is a control desk for each of the two switching engineers. They are equipped with keyboards for calling or answering any control telephone in the area, with overriding priority over inter-office traffic. On the loading desk, which is in front of the feeder flow diagram and usually has accommodation for two engineers, chart recorders indicate area net transfer, area total generation and system frequency. Other instruments indicate rate of change of system frequency and daylight intensity as telemetered from the main industrial load centre of the area. The loading desk also incorporates a 16-way message instructor for the various out-stations; and on an adjacent console there are individual power station MW generation instructors.

POWER STATIONS

On each power station control desk there is a control telephone and local telemeter indications, similar to those telemetered to the GCC, of the stations' total generation in MW "sent out" and "gross" MVAr. In addition there is an indicator that responds to the GCC loading engineer's generation instructions, combined lamps and twist buttons for the display and acceptance of visual instructions transmitted by the GCC loading engineer, and a button to re-light the last instruction received.

Attended transmission stations can be provided with visual instruction facilities for load reduction and restoration purposes. Unless remotely controlled by the Area Board concerned, unattended minor stations are controlled by means of the standardised system over the Grid control network by the Generating Board from the associated major stations which are usually generating stations and therefore attended. As a precaution against rented line failure, however, this method of control is reinforced at the minor stations by automatic reclosure of the grid circuit-breakers.

SIGNALLING

As already mentioned, the standardised system continues the established practice of using rented G.P.O. lines as the main channels of communication. Lines between stations and GCC's can be up to 150 miles long, but mostly they are short enough to allow earth return d.c. phantom signalling, which is inexpensive and does not interfere with speech or voice-frequency telemeter signalling; it is unaffected by line reversal and at stations where isolation is not required the earthed positive pole 50 V station batteries are used for line signalling. As this precludes the polarising of train marking impulses they are marked by increasing the make period from 50 to 160 millisec. Unmarked pulses are transmitted at 10 a second with equal make and break periods.

On lines where d.c. earth return signalling cannot be used, the established practice of using 300 c/s tone signalling is retained with the speech band restricted at the lower end to 400 c/s and interrupted 480 c/s for the ringing and busy tones. This system is employed between GCC, parent and satellite stations to minimise impulse distortion on trains relayed by parent stations and because inter-station dialling between parent and satellite stations requires the direct current channels. The speech band is also restricted to an upper limit of 2,000 c/s, to allow the simultaneous transmission of speech and telemetering at 2,220 and 2,340 c/s.

From the GCC's the direct current or 300 c/s signalling channel is used to select visual messages or generation instructions at the stations and to set up telephone calls. The same channels are used from the stations to signal telephone calls and the indications of circuit-breakers, automatic isolators, overloaded feeders, direction (import or export) of telemetered power transfers, loss of telemeter channels between stations and acknowledgment of visual message instructions. To prevent lock-out due to channel congestion during heavy traffic, the selection, indication and telephone signal trains use the common signalling channel in turn.

When an indication train is transmitted from a satellite station it is relayed to the GCC by the parent station, which, together with the other satellite stations is then prevented from sending an indication train. With an additional group selection code, selection trains from the GCC are relayed by the parent station into the local equipment or to the selected satellite station. Fig. 3 shows an apparatus room of a GCC.

TELEMETERING

With the demand for more telemeters in the early 1940's, telemeters which required individual signalling channels were superseded by multiplex systems. These served their purpose but it was evident that telephone relays were not satisfactory for continuous multiplex operation. Accordingly, an electronic multiplex telemetering system was adopted in the standardised system. This uses start-stop time division with 20 millisec marking and scans ten meters in 200 millisec, three times a second. In the GCC's the decoded impulses operate electronic telemeters to produce d.c. voltages directly proportional to the impulse rates. Indications of the direction of telemetered power flow are transmitted by the general indicating system as a point indication. This allows the full capacity of the multiplex system to be used for telemetering.

A recent development provides for the transmission of signals, initiated by high-speed line protection, to accelerate the operation of remote distance protection equipment or to unlock inhibited directional overcurrent relays at remote transformer feeder stations.

★ ★ ★

In our article describing the 550 MW turbo-generator for the projected station at Thorpe Marsh (ENGRG. 9 May, p. 586) a specific volume figure of 12·6 cu. ft per kW was quoted and compared with a corresponding figure of 28·6 cu. ft for Skelton Grange A. It should be made clear that the figures for the complete stations should be 24 cu. ft per kW, and 62·5 cu. ft per kW respectively.

Engineering at Home

DOMESTIC CLIMATOLOGY

Indoor temperature and relative humidity have an important influence on house structure and furnishings. For example, low relative humidity can cause shrinkage of woodwork and damage to the glued joints of furniture; and an excess of moisture results in condensation on cold surfaces, such as exterior walls and windows, causing wetting of the window frames and water streaks on the interior finish. Condensation occurring within the wall and ceiling structure, or in the attic, results in wetting of the insulation and wood: loss of insulation value and accelerated deterioration of the structure follow.

The heating requirements of a house and the humidity conditions that prevail depend both on its design and construction and on the outdoor weather. Aspects of design, such as size, number of storeys, total window area, and type of heating system, will have an effect. Heat transmission through the structure depends largely on the amount of insulation used and the outdoor air temperature. Air tightness of windows and doors, together with outdoor temperature and wind conditions, largely determine the amount of infiltration of outdoor air, which produces heat and moisture losses from the house. The orientation of the house and the relative window area facing south and west influence the amount of solar heat gain in the winter, which will in turn affect the fuel consumption.

The indoor climate of a house depends on the occupants too. In exactly similar houses, the temperature and relative humidity conditions can vary widely depending on the number of occupants, their comfort requirements, their appliances, and their personal habits. No two families " operate " a house the same way. There are variations in the opening of windows at night, in the day and night settings of the heating thermostat, and in the use and proper maintenance of heating and humidifying equipment; as well as differences in the frequency and method of cooking, of washing and drying clothes, and in the use of the fireplace and the kitchen exhaust fan. All have an influence on the " indoor climate " and upon the heating and moisture requirements of the house.

Because the effects of these variables on the indoor climate of houses have not been investigated fully, the National Research Council, Canada, are engaged on a programme of research on the subject. In Canada, it is known that during the heating season the air temperature is likely to be in the range of 70-75° F; it is expected that the maximum relative humidity of the air in houses will generally be limited to the value at which condensation occurs on the window surfaces. However, there is a lack of specific information on the actual indoor climate which exists, summer and winter, not only in the occupied portion of the houses but also in attics and basements.

The project has been initiated by the Division of Building Research, Ottawa. Its first stages comprise a survey of actual temperature and relative humidity conditions in the occupied portion of houses, and a study of how the indoor climate is affected by outdoor weather conditions, by the design and tightness of house construction, by the use of heating and humidifying equipment, and by the influences of occupancy itself. The houses at present under observation are in the Ottawa area, in Saskatoon, and in Vancouver—representing moderately severe, severe, and moderate winter climates respectively. The results of a similar survey of occupied houses in Camp Gagetown, conducted the previous winter, will also be incorporated.

All houses have been equipped with temperature and relative humidity recorders to give continuous records of the indoor climate of the living area. Records of fuel consumption, furnace performance and efficiency, and of oil-burning time-on are being kept for the Ottawa houses, while the performance and water consumption of humidifiers are being studied in two of these houses equipped with warm-air furnaces. Data on the performances of the gas-fired furnaces in houses under study at Saskatoon are also being taken.

For the correlation of outdoor and indoor climate conditions the daily weather records are being used to compute the mean outdoor air temperature, moisture content, degree days, average wind speed and direction, and the intensity of solar radiation. The study is to be extended to include temperature and relative humidity conditions in attics and basements.

ECONOMIC BUILDING

The variety of modern building materials and techniques gives a new freedom in design. But the design that is the most economical in initial and subsequent costs is not always easy to find. Building Research Station Digest 109, " Building Economies: Cost Planning," outlines an approach to cost planning that takes into account initial costs and maintenance and running costs. Five pages make up the leaflet and in such space it is necessary to bring to light general principles rather than to lay down specific procedures. Also the report points out that there is " a real shortage of design cost data and much can be done to alleviate this shortage by the publication of such data, in suitable detail."

Cost planning consists of predicting the cost consequences of design decisions. The problem is complicated by the fact that several interests are involved, and a saving in one may lead to extra expense for another. Also what is in the interest of the owner is not necessarily in the interest of the user or the community. Planning has to be considered at a number of levels, some of which call for administrative rather than design decisions. Two main sections of the report deal with initial costs and annual costs. A further section brings out the varied interests of owners, users, and the community.

The success of the designer in obtaining economies in planning and structure is judged by the building user in terms of the price of the useful space provided. The range of such prices is often very wide, and comparisons can be very instructive. It is often found that large differences result from design limitations imposed by the client, who sometimes gains very little by them.

The annual charge is of great importance to the user. A cheap building may in the long run be far more expensive than one with higher initial costs. So far, says the report, the only type of building that has been studied at all thoroughly from the aspect of maintenance is local-authority housing. For this type of building the equivalent capital cost of maintenance compared with initial costs is comparatively low, the only exception being water services and external painting. Some reduction in the latter can probably be achieved by the use of materials not requiring regular painting.

As an example of the considerations that must be taken into account in estimating service costs, the report points out that the savings to be achieved by reducing the width of estate roads and by substituting footpaths may be offset by the extra costs incurred by carrying the dustbins and commercial delivery, the substitution of hand for mechanical road sweeping, and the making good of damage likely to be caused by vehicles crossing kerbs and grass.

The report considers that it is doubtful how far an assessment of maintenance, service and other running costs influences rent. Property owners, therefore, attach primary importance to reducing initial costs. Taxation treats running costs more favourably and, therefore, businessmen who are owner-occupiers tend to be more interested in reducing the latter than the former. The community is interested in value for money in terms of actual resources, labour and materials.

NEW DOMESTIC BALL VALVE

A new ball valve, designed and developed at Garston by the Building Research Station, DSIR, is now available to industry for manufacture, having completed its full-scale trials satisfactorily. The patent rights covering this ball valve are being transferred from DSIR to the National Research Development Corporation, through whom manufacturing rights under licence can be offered to industry.

The main features of the Garston design are that it eliminates damage by cavitation corrosion of the moving parts and reduces noise. Its design includes a smooth, flared nylon nozzle and a resilient diaphragm which stops the flow of water when pressed against the nozzle by a plunger. The diaphragm, which is made of rubber, has the advantage of keeping the moving parts dry and free from encrustation and corrosion. The rubber itself has a long life expectation as the wet, cold, and dark conditions are ideal. Movement of the plunger is controlled by the usual float on a hinged arm which, at its free end, is bent down at a right angle. The valve is likely to be as cheap as existing types.

A stand against the dictum that high-quality audio amplifiers must have high output powers is taken by Mr. P. J. Baxandall, author of " Low-cost High-quality Amplifier." He considers that an amplifier rated at 5 watts is quite adequate for domestic use, and gives details of the construction of such a unit. The publication is available from Iliffe and Sons Limited, Stamford Street, London, S.E.1, price 3*s.* 6*d.*

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